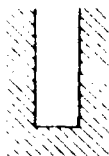


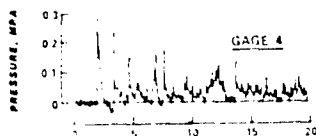
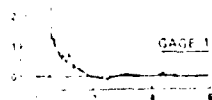


US Army Corps
of Engineers

AD-A157 003



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EXPANSION CHAMBER



TECHNICAL REPORT SL-84-23

AIRBLAST ATTENUATION IN ENTRANCEWAYS AND OTHER TYPICAL COMPONENTS OF STRUCTURES

SMALL-SCALE TESTS DATA REPORT 2

by

Charles D. Little, Jr.

Structures Laboratory

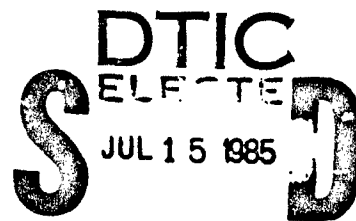
DEPARTMENT OF THE ARMY
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PO Box 631, Vicksburg, Mississippi 39180-0631

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Under Project 4A161102AT22, Task BO, Work Unit 003

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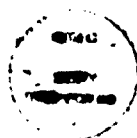
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) / Airblast attenuation through entranceways into structural components was in- vestigated in a small-scale explosive test series during 1983. Thirty tests were performed with steel constructed models of square cross-section tunnels in configurations typically found in field fortifications and personnel shelters. Model structures included tunnels with 15 cm and 30 cm entrance widths and 42 and 17 tunnel diameters long, respectively, blast shields in front of tunnel entrances, and abrupt expansions in entranceways. Spherical charges ranging (Continued)		

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20. ABSTRACT (Continued).

from 113 to 907 grams were detonated outside the tunnel entrances in end-on and side-on geometries. Airblast measurements were made at various positions along the tunnel walls.

Pressure-time histories with corresponding integrated impulse histories and tabulated peak values are presented. Plots of pressure versus scaled distance are presented, along with comparisons of data from previous tests of the airblast penetration program which investigated airblast attenuation in tunnels of round cross-section.

As the distance from the blast source increases, the pressure and impulse values decrease. The data from the previous tests are compared with the data from the current tests. The results show that the airblast attenuation in tunnels of round cross-section is similar to that in tunnels of rectangular cross-section.

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PREFACE

This investigation was sponsored jointly by the Office, Chief of Engineers (OCE), U. S. Army, and by the Air Force Engineering and Services Center, Tyndall AFB, U. S. Air Force. The work was performed under OCE R&D Project 4A161102AT22, Task area B0, Work Unit 003.

The investigation was conducted during the period July 1983 to September 1983 by personnel of the Structures Laboratory (SL), U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, MS. The field tests were conducted by C. D. Little, Jr., R. Walters, S. B. Price, and J. Stout of the Explosion Effects Division (EED).

L. T. Watson and L. Sadler of the WES Instrumentation Services Division (ISD) provided field instrumentation support and instrument calibration, respectively.

Data processing was performed by J. T. Brogan and D. W. McAlpin, EED.

The investigation was under the general supervision of J. W. Brown, former Chief, EED, J. D. Day, Chief, EED, and B. Mather, Chief, SL. COL Tilford C. Creel, CE, was Commander and Director and F. R. Brown was Technical Director of WES during the investigation.

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CONVERSION FACTORS, METRIC (SI) TO U. S. CUSTOMARY
UNITS OF MEASUREMENT

Metric (SI) units of measurement used in this report can be converted to
U. S. customary units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
Centimetres	0.3937	inches
Kilograms	2.205	pounds (mass)
Metres	3.281	feet
Metres per second	3.281	feet per second
Pascals	0.000145	pounds (force) per square inch

AIRBLAST ATTENUATION IN ENTRANCEWAYS AND OTHER TYPICAL COMPONENTS
OF STRUCTURES: SMALL-SCALE TESTS DATA REPORT 2

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Many permanent shelters and field fortifications have openings into which airblast from near-miss conventional warhead explosions may propagate to produce damage and injury to the interior. A large amount of research has been conducted for long duration pulses simulating nuclear detonations (Reference 1). But before this test program only a small amount of information was available for high pressure, extremely short duration pulses produced by conventional weapons. Experimental data in this area are limited to a few shock tube tests (Reference 2), and limited small-scale high explosive tests (References 3 and 4). Important differences between these results and the nuclear blast simulations have been noted, and calculational techniques developed for the long duration pulses have often had poor success in predicting the attenuation of high pressure, short duration pulses.

This investigation was designed to obtain information needed to determine fundamental characteristics of short duration shock penetration into structures through openings.

1.2 OBJECTIVE

The objective of this investigation was to develop an experimental data base for the airblast produced by conventional high explosive detonations which intrudes into structures through air entrainment systems, doors and other openings. This information will provide an experimental basis for the development

of airblast prediction methods for the selection of blast doors and blast valves and the design of the geometrical configuration of personnel and air entrainment entranceways to suppress blast.

The objective of this report is to present the experimental data obtained in the small-scale explosive test program and a brief and limited analysis of some basic observations.

This report describes the second phase of the experimental effort consisting of a comprehensive small-scale explosive test program conducted in the summer of 1983.

1.3 PURPOSE

The purpose of the 1983 series of the investigation was to enhance the existing data base by providing test data from square tunnels, many tunnel diameters in length. The results will be useful in correlating airblast attenuation in long square tunnels with that of long round tunnels (investigated in 1981 and 1982 series). The effects of abrupt expansions in entranceways and reflections off entrance shields from side-on bursts were also investigated.

CHAPTER 2

EXPERIMENTAL PLAN

2.1 TEST PROGRAM

The experimental program consisted of 30 spherical charges, ranging from 113 to 907 g of Composition C-4 explosive, detonated outside the entrance of tunnels of square cross-section. The model structures consisted of a 30 cm square tunnel 17 tunnel diameters in length and a 15 cm square tunnel 42 tunnel diameters in length. Seven of the 22 tests of the 30 cm square tunnel included a blast shield placed in front of the tunnel entrance. Side-on bursts were used with this configuration to access the effects of reflected blast waves from the entrance shield which intrude into the tunnel opening. Seven of the 30 cm square tunnel tests included a 15 cm square contraction insert which was placed in the entrance of the 30 cm tunnel. The purpose of the insert was to provide an abrupt expansion from a small tunnel to a larger tunnel. End-on burst configurations were used for all tests except for the side-on bursts used with the entrance shield configurations. Details of test parameters are given in Table 2.1.

The test structures were fabricated from steel plate and heavy wall (0.95 cm thickness) steel tubing. Pressure transducers were mounted from the outside of the tunnel so that the sensing surface was flush with the inside wall to obtain side-on blast measurements.

The tests were performed at the Waterways Experiment Station Big Black Test Site near Vicksburg, MS.

2.2 STRUCTURE DESCRIPTION

Shots 1-15 of the 1983 series used a 30 cm square tunnel that was

5.18 meters (17 feet) in length (Figure 2.1). Figure 2.2 illustrates the dimensions and gage locations of the tunnel. Shots 3, 5-8, 14, and 15 included a 0.6 m x 0.6 m x 1.27 cm (2 ft x 2 ft x 1/2 in.) entrance shield placed 0.3 and 0.6 meters (1 and 2 feet) in front of the tunnel entrance (Figure 2.3). Entrance shield stand-off distances are listed in Table 2.1.

Shots 16-22 used the same tunnel as Shots 1-15 with the addition of a square tunnel contraction insert (Figure 2.4). The insert reduced the tunnel entrance from 30 cm to 15 cm for a distance of 30 cm and then abruptly returned to the 30 cm square cross-section. Figure 2.5 shows the tunnel, insert, and gage locations for Shots 16-22.

Shots 23-30 used a 15 cm square tunnel that was 6.4 meters (21 feet) in length (Figure 2.6). The tunnel was used to determine the adequacy of scaling routines between the 15 cm and 30 cm tunnels. Dimensions and gage locations are shown in Figure 2.7.

2.3 INSTRUMENTATION AND DATA PROCESSING

2.3.1 Transducers. Airblast overpressures for the 1983 series of tests were measured with Kulite HKS-375 pressure sensors in ranges from 3.45 to 34.5 MPa (500 to 5,000 psi) with natural frequencies of 350 to 675 kHz, respectively, and Kulite XT-190 pressure sensors in ranges from 0.69 to 1.38 MPa (100 to 200 psi) and with natural frequencies of 160 to 200 kHz, respectively.

The transducers were placed in specially designed mounts to reduce vibration and noise caused by shock waves traveling down the tunnel walls. The mount shown in Figure 2.8 was used in locations where high pressure, multiple peak shocks occur, such as near the tunnel entrance. This mount consisted of an aluminum casing and a solid nylon insert. In areas of lower pressure, smooth peaked shocks the mount shown in Figure 2.9 was used. It consisted of

an aluminum case and a nylon insert with a RTV silicon rubber annulus between the aluminum and nylon. Figure 2.10 shows the gage mount adapter for the XT 190 transducers. The transducer/mount assembly was mounted in the tunnel wall flush with the inside surface.

The gages were connected to a junction box approximately 30 meters (100 feet) away with large Beldon 4 conductor shielded cable. The junction box was connected to the recording system with approximately 45 meters (150 feet) of twenty twisted pair, individually shielded cable.

2.3.2 Recording System. The analog signals for the 1983 series tests were recorded using a Sangamo Sabre V 32-track FM wide band Group I magnetic tape recorder with a flat frequency response from dc to 80 kHz. Signals were conditioned with WES developed amplifiers with flat frequency response from dc to 100 kHz.

2.3.3 Data Processing. The analog data signals were converted to digital format using the WES high-speed analog-to-digital converter. All channels were digitized at a rate of 500 kHz. Baseline corrections were applied when necessary to produce zero impulse at shock front arrival.

2.4 TEST PARAMETERS

Composition C-4, a military high explosive, was used for all tests. Most charges were detonated in an end-on position in front of the entrance. Side-on bursts were also used with the entrance shield configurations. Figure 2.11 illustrates the notation used to describe the charge location. Explosive weight, charge location, and entrance shield stand-off distances for each test are shown in Table 2.1. Other information such as shot date, time, and air temperature are listed in Table 2.2.

TABLE 2.1 1983 AIRBLAST PENETRATION TEST CONFIGURATIONS

Shot No.	Charge Weight (gm)	Nominal Entrance Press (MPa)	Charge Location (m)	Entrance Shield Stand-off (m)
<u>LONG TUNNEL, 5.18 m LONG, 30 cm SQUARE</u>				
1	907.2	6.89	End-on r = 0.37	--
2	907.2	3.45	End-on r = 0.56	--
3	340.2	10.34	Side-on h = 0.19, r = 0.15	0.61
4	340.2	3.45	End-on r = 0.40	--
5	340.2	6.89	Side-on h = 0.37, r = 0.15	0.30
6	340.2	6.89	Side-on h = 0.37, r = 0.15	0.61
7	340.2	3.45	Side-on h = 0.59, r = 0.15	0.61
8	340.2	3.45	Side-on h = 0.59, r = 0.15	0.30
9	113.4	3.45	End-on r = 0.28	--
10	907.2	1.38	End-on r = 0.88	--
11	340.2	1.38	End-on r = 0.63	--
12*	113.4	1.38	End-on r = 0.44	--
13	340.2	0.69	End-on r = 0.88	--
14	340.2	1.38	Side-on h = 0.88, r = 0.15	0.3
15	340.2	1.38	Side-on h = 0.88, r = 0.15	0.61
<u>LONG TUNNEL, 5.18 m LONG, 15 cm TO 30 cm ENTRANCE</u>				
16	113.4	0.69	End-on r = 0.61	--
17	340.2	0.69	End-on r = 0.88	--
18	907.2	0.69	End-on r = 1.21	--
19	340.2	1.38	End-on r = 0.63	--
20	113.4	1.38	End-on r = 0.44	--
21	113.4	3.45	End-on r = 0.28	--
22	340.2	3.45	End-on r = 0.40	--
<u>LONG TUNNEL, 6.4 m LONG, 15 cm SQUARE</u>				
23	907.2	0.69	End-on r = 1.21	--
24	113.4	1.38	End-on r = 0.44	--
25	340.2	1.38	End-on r = 0.63	--
26	113.4	3.45	End-on r = 0.28	--
27	907.2	1.38	End-on r = 0.88	--
28	113.4	6.89	End-on r = 0.26	--
29	340.2	3.45	End-on r = 0.40	--
30	907.2	3.45	End-on r = 0.56	--

* No data from Shot 12.

TABLE 2.2 SUPPLEMENTAL TEST INFORMATION - AIRBLAST
PENETRATION 1983 SERIES

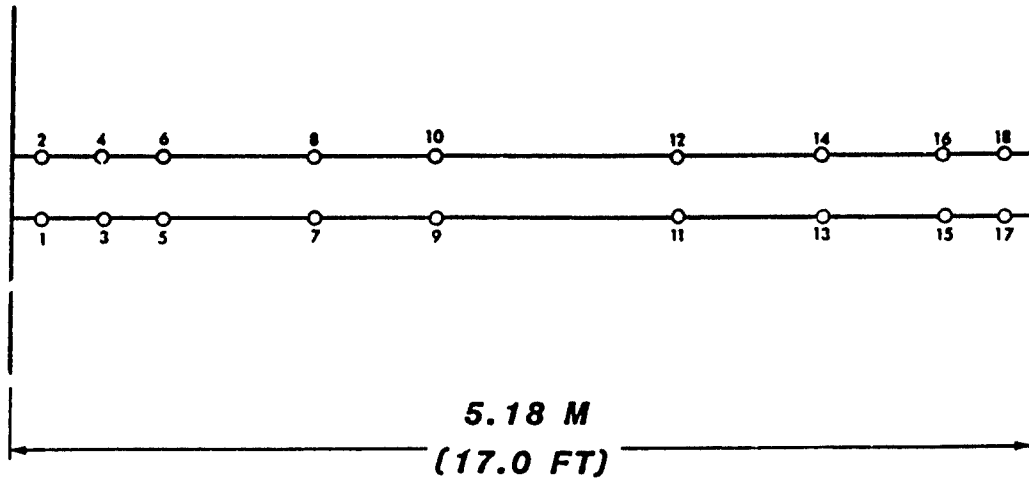
Shot No.	Date	Time	Air Temperature (°C)	Barometric Pressure (cm Hg)
1	28 Jul 83	1137	34	76.6
2	28 Jul 83	1440	35	76.6
3	3 Aug 83	1025	27	--
4	3 Aug 83	1400	32	76.2
5	4 Aug 83	1119	31	76.7
6	4 Aug 83	--	32	76.7
7	8 Aug 83	1056	31	76.2
8	8 Aug 83	1312	33	76.2
9	9 Aug 83	1014	27	76.3
10	9 Aug 83	1220	34	75.8
11	10 Aug 83	1320	34	75.9
12*	10 Aug 83	1409	34	75.9
13	10 Aug 83	1505	34	75.9
14	11 Aug 83	1107	31	76.2
15	11 Aug 83	1247	32	76.2
16	16 Aug 83	1359	34	75.9
17	17 Aug 83	1043	32	76.2
18	17 Aug 83	1232	35	75.9
19	17 Aug 83	1316	35	75.9
20	19 Aug 83	1125	33	76.2
21	19 Aug 83	1249	35	76.2
22	19 Aug 83	1316	35	76.2
23	24 Aug 83	1057	34	76.2
24	24 Aug 83	1226	37	75.9
25	24 Aug 83	1255	37	75.9
26	30 Aug 83	1045	33	75.8
27	30 Aug 83	1355	34	75.7
28	30 Aug 83	1420	34	75.7
29	31 Aug 83	1330	33	75.7
30	31 Aug 83	1415	33	75.7

* No data from Shot 12.



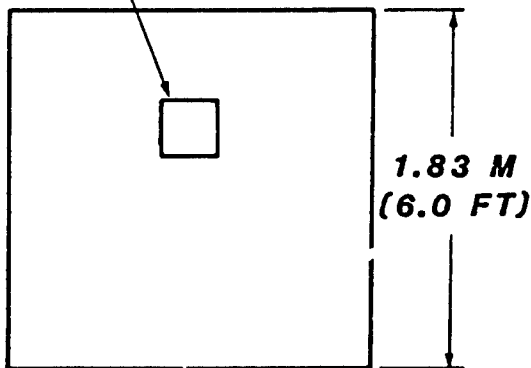
Figure 2.1 30 cm Square Tunnel, Length = 5.18 m

TOP VIEW



FRONT VIEW

30 cm x 30 cm



GAGE NO.	DISTANCE FROM FACE	
	cm	(ft)
1	15.24	(0.5)
2	15.24	(0.5)
3	45.72	(1.5)
4	45.72	(1.5)
5	76.20	(2.5)
6	76.20	(2.5)
7	152.40	(5.0)
8	152.40	(5.0)
9	213.36	(7.0)
10	213.36	(7.0)
11	335.28	(11.0)
12	335.28	(11.0)
13	411.48	(13.5)
14	411.48	(13.5)
15	472.44	(15.5)
16	472.44	(15.5)
17	502.92	(16.5)
18	502.92	(16.5)

Figure 2.2 30 cm Square Tunnel Dimensions and Gage Locations

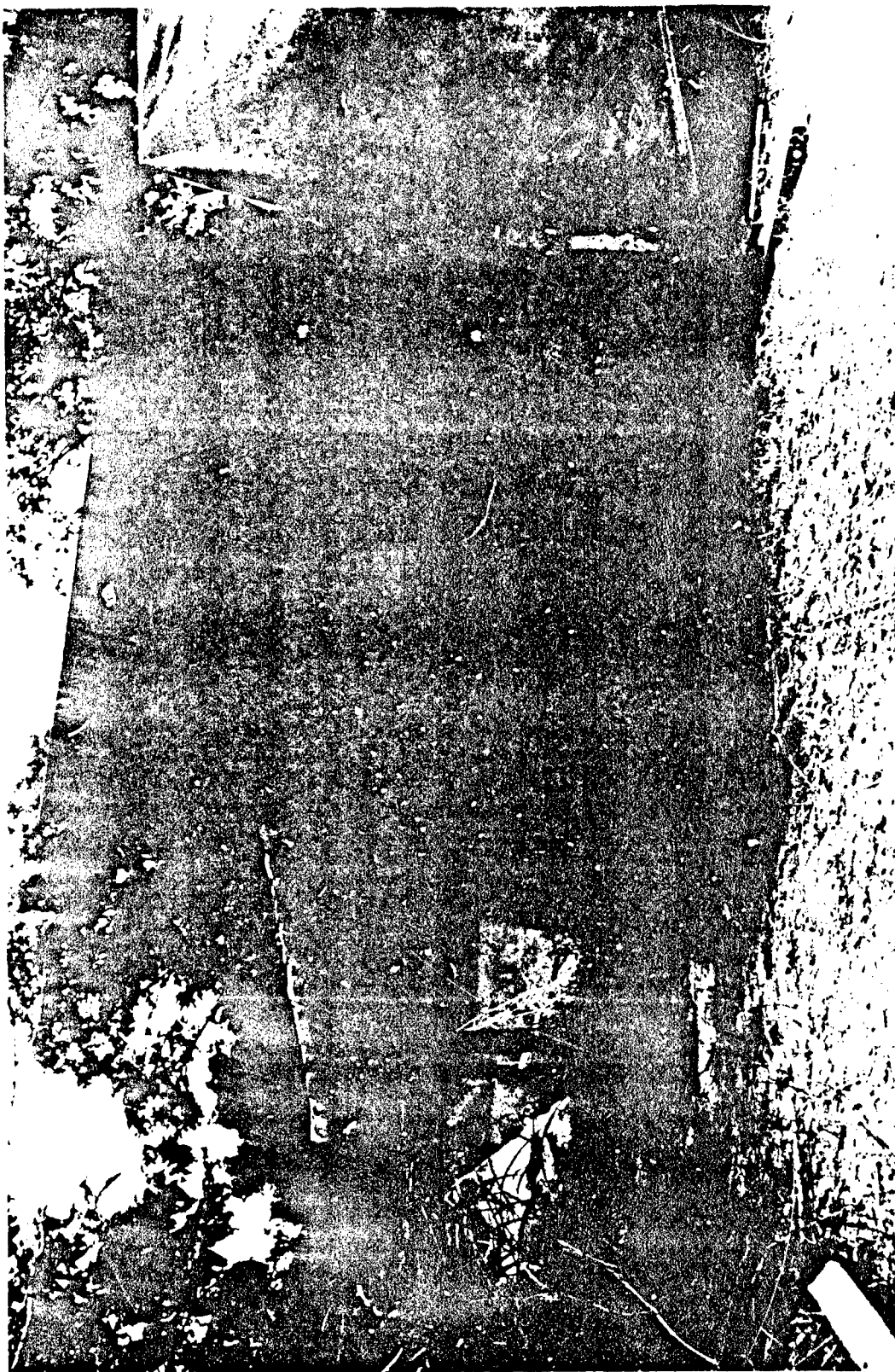


Figure 2.3 30 cm Square Tunnel with Entrance Shield

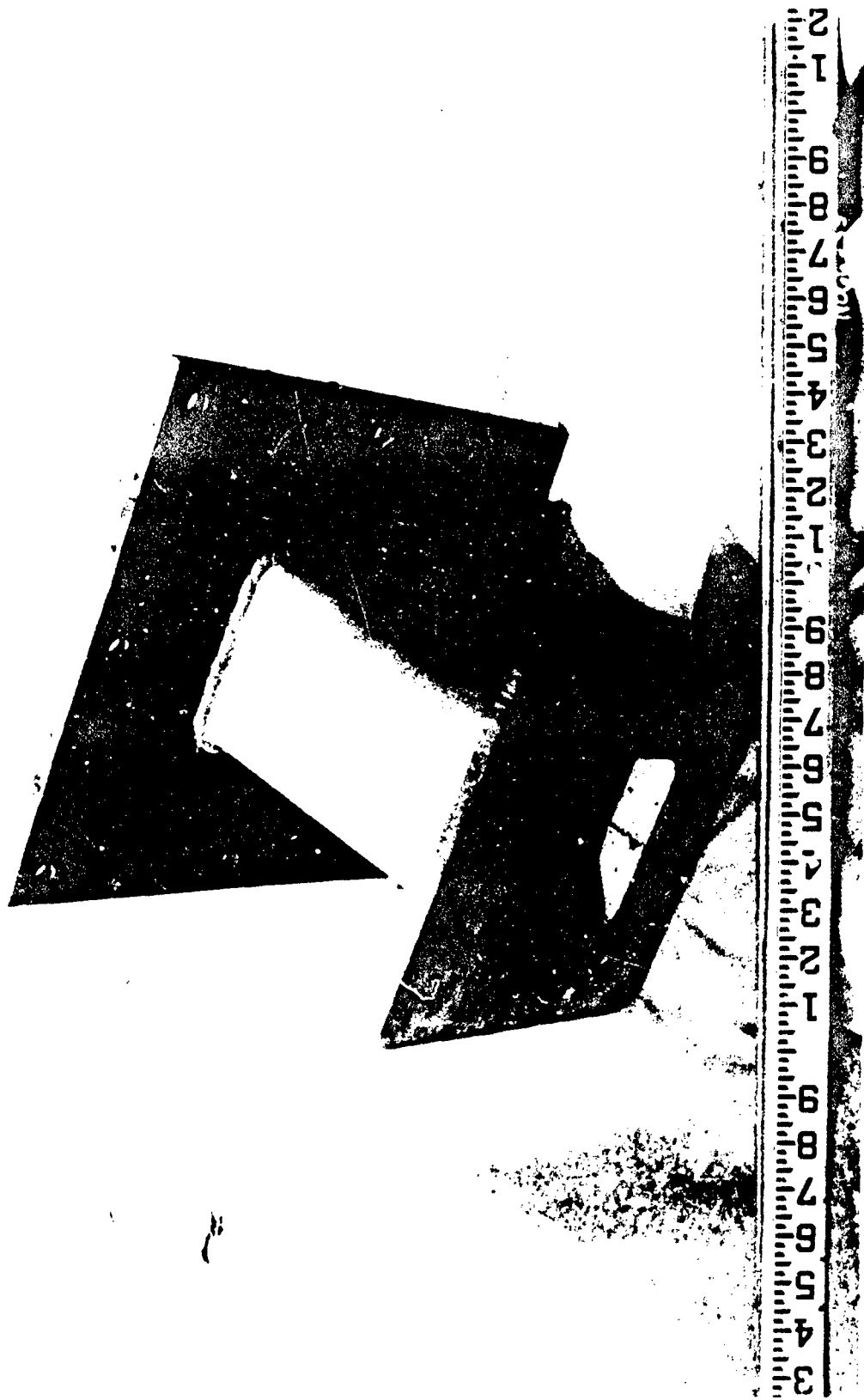
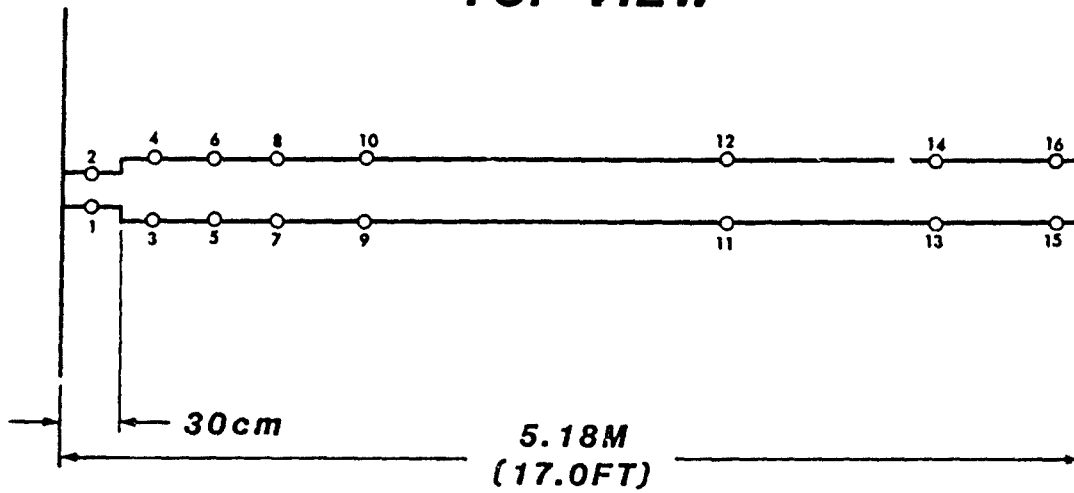
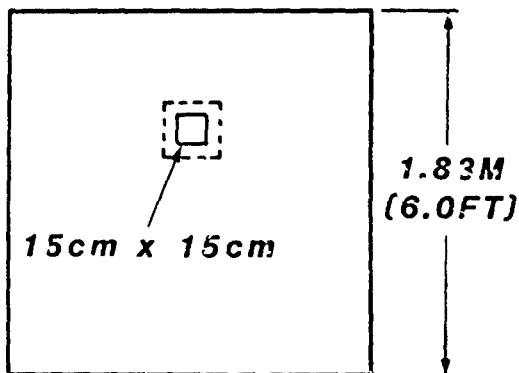


Figure 2.4 Square Tunnel Contraction Insert (15 cm)

TOP VIEW



FRONT VIEW



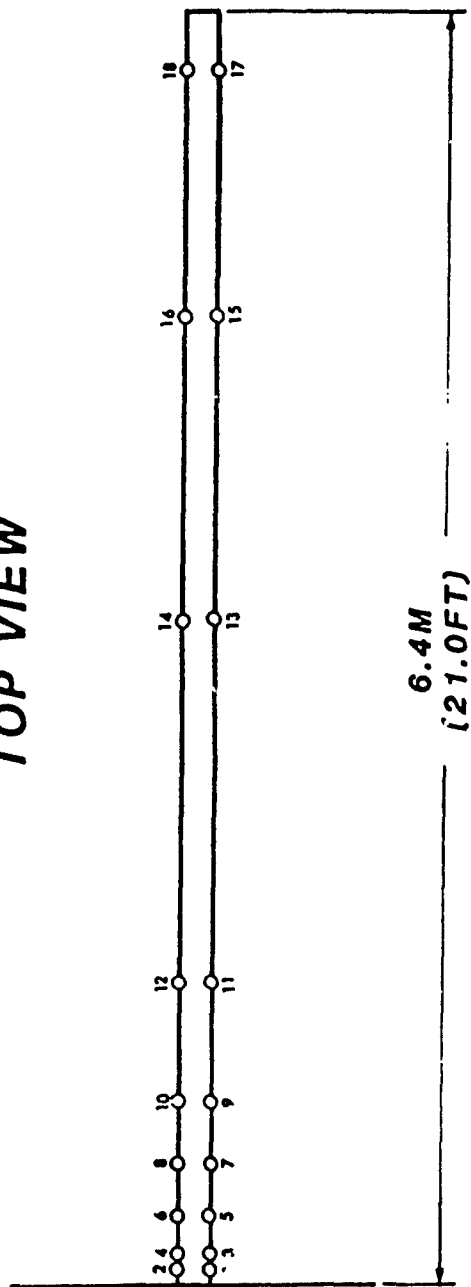
GAGE NO.	DISTANCE FROM FACE	
	cm	(ft)
1	15.24	(0.5)
2	15.24	(0.5)
3	45.72	(1.5)
4	45.72	(1.5)
5	76.20	(2.5)
6	76.20	(2.5)
7	106.68	(3.5)
8	106.68	(3.5)
9	152.40	(5.0)
10	152.40	(5.0)
11	335.28	(11.0)
12	335.28	(11.0)
13	441.96	(14.5)
14	441.96	(14.5)
15	502.92	(16.5)
16	502.92	(16.5)

Figure 2.5 30 cm Square Tunnel with 15 cm Contraction Insert
Dimensions and Gage Locations

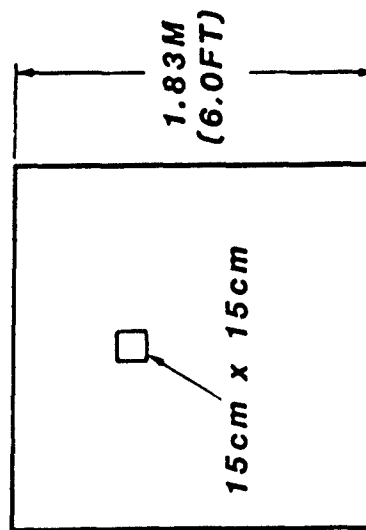


Figure 2.6 15 cm Square Tunnel, Length = 6.4 m

TOP VIEW

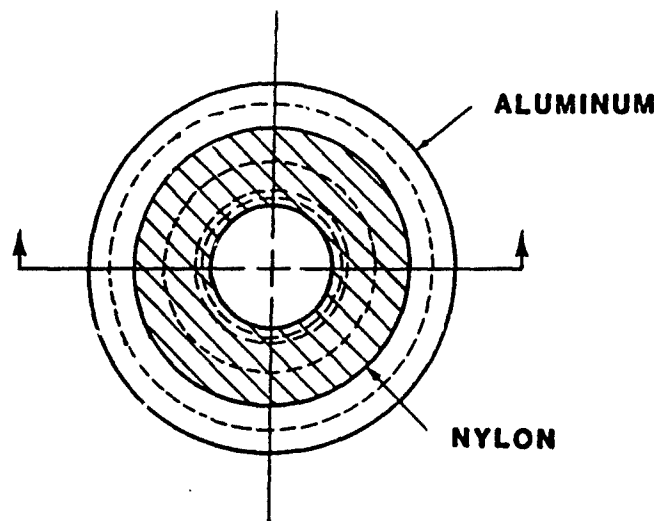


FRONT VIEW



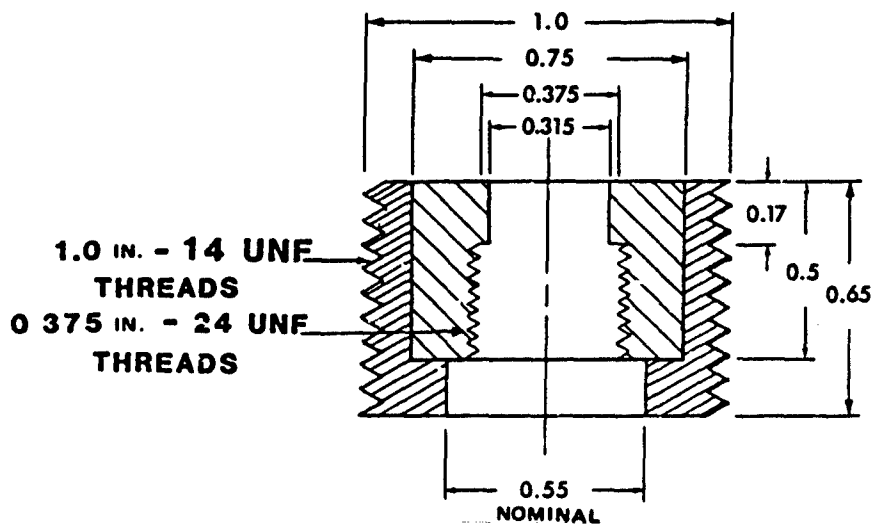
GAGE NO.	DISTANCE FROM FACE	
	cm	(ft)
1	7.62	(0.25)
2	7.62	(0.25)
3	15.24	(0.5)
4	15.24	(0.5)
5	35.66	(1.17)
6	35.66	(1.17)
7	60.96	(2.0)
8	60.96	(2.0)
9	91.44	(3.0)
10	91.44	(3.0)
11	152.40	(5.0)
12	152.40	(5.0)
13	335.28	(11.0)
14	335.28	(11.0)
15	487.68	(16.0)
16	487.68	(16.0)
17	609.60	(20.0)
18	609.60	(20.0)

Figure 2.7 15 cm Square Tunnel Dimensions and Gage Locations



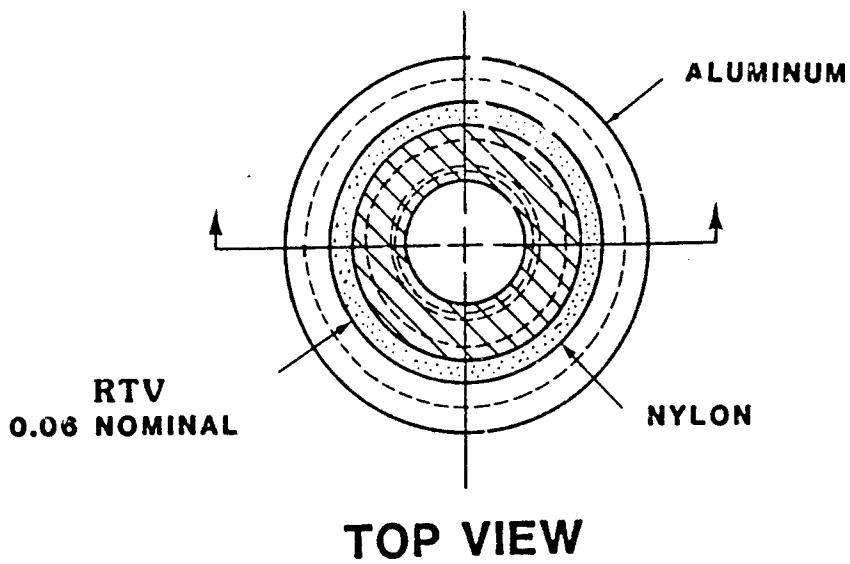
TOP VIEW

**ALL DIMENSIONS
IN INCHES**



FRONT VIEW

Figure 2.8 Nylon-Aluminum Gage Mount



ALL DIMENSIONS
IN INCHES

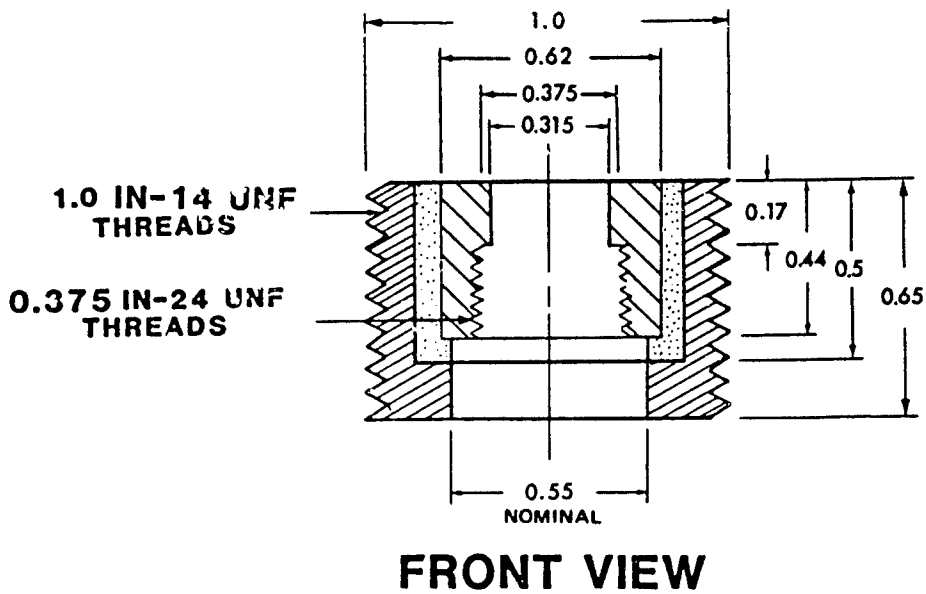
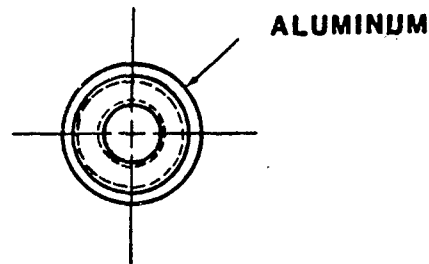
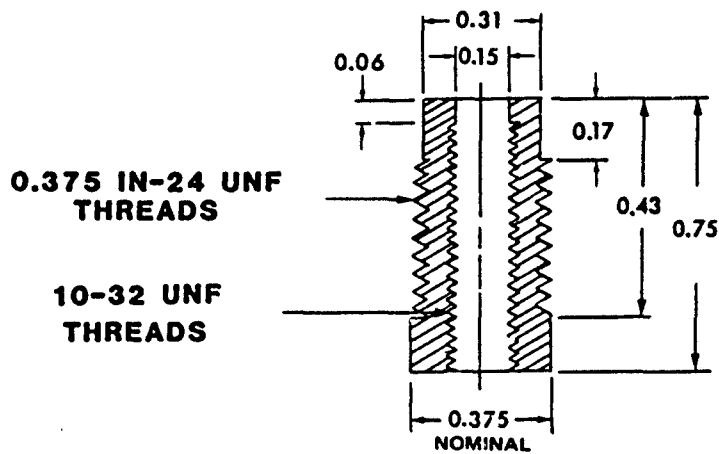


Figure 2.9 Nylon-Aluminum-RTV Gage Mount



TOP VIEW

**ALL DIMENSIONS
IN INCHES**



FRONT VIEW

Figure 2.10 Adapter for XT-190 Transducer

CHARGE LOCATION

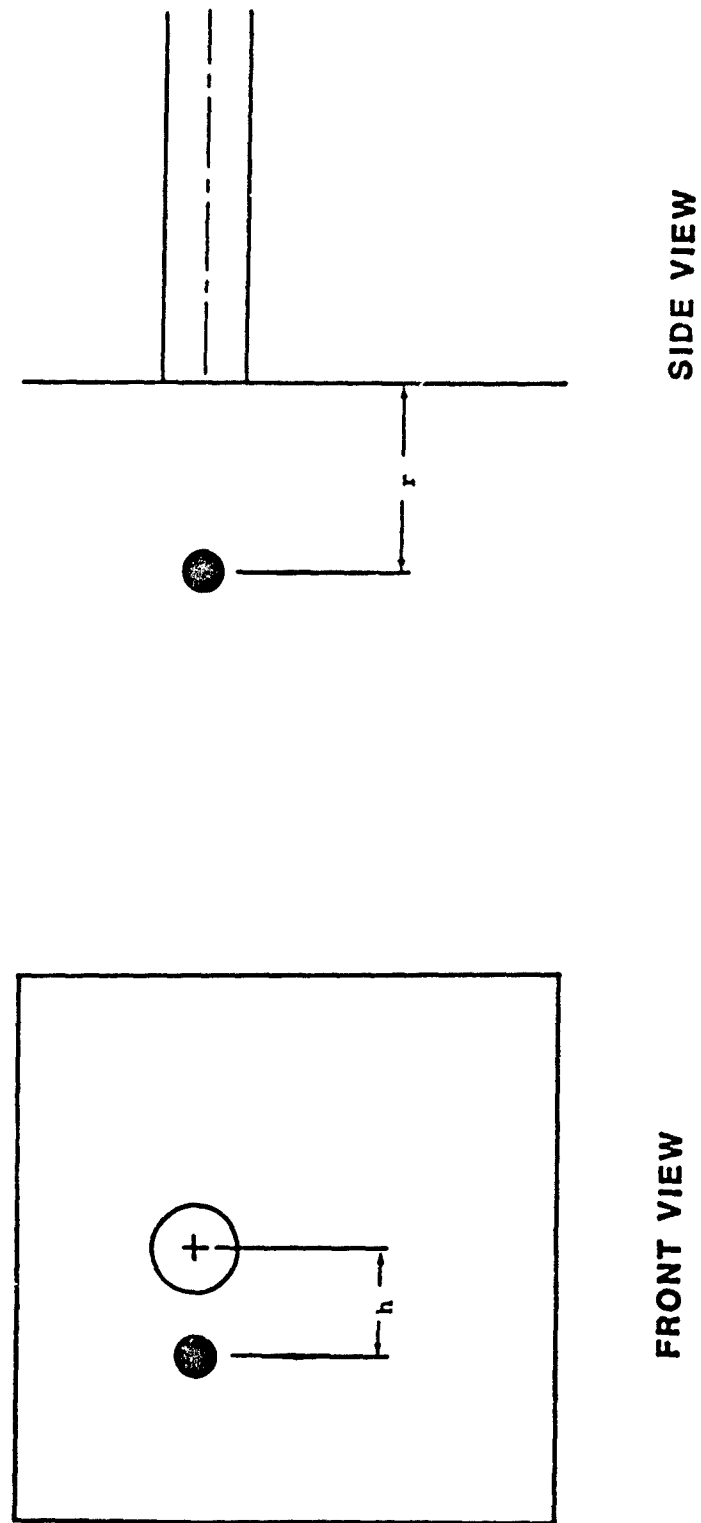


Figure 2.11 Charge Geometry

CHAPTER 3

RESULTS

3.1 WAVEFORMS AND TABULATED DATA

The measured pressure-time histories and corresponding impulse-time histories for the 1983 series tests are given in Appendix A. Information found in the waveform label includes shot number, tape channel number, measurement number, test series title, test component, digitizing rate, and processing date.

Appendix B contains the tabulated parameters illustrated in Figure 3.1 for each test. It should be noted that the impulse listed for the second pulse is the total impulse and not the increase in impulse due to the second pulse.

3.2 OVERVIEW OF DATA

In general, there was a high percentage of data recovery for all tests of the 1983 series. With the exception of Test 12, approximately 80 to 90 percent of the data was recorded in an useable form. No data was recovered from Test 12 due to instrumentation difficulties.

Waveform characteristics observed for this series were very similar to those observed for the 1981 and 1982 series. Waveforms near the tunnel entrance indicate a complex pattern of reflections and diffractions which result in high peaked, short duration pulses, many which contain two peaks. This phenomena appears to be a function of the curvature of the shock front at the entrance of the tunnel. For a given entrance pressure level, smaller charges near the entrance tend to produce this phenomena more than larger charges which are located at a greater radius from the tunnel entrance.

As the airblast shock front attenuates down the tunnel, the sharp-peaked

pulses approach a more stable, uniform condition. Observations from all series tests of the investigation show this stable condition to occur approximately 5 to 8 tunnel diameters from the tunnel entrance. Charges located off center of the tunnel entrance can increase the number of tunnel diameters required for stabilization from test to test. Airblast records at and beyond this stabilization point are much more consistent than records near the tunnel entrance.

The reflected pulse from the end of the tunnel can be observed easily from the latter waveforms of each test. The reflected pulses considerably increase the total impulse observed in the end of the tunnel.

Peak pressure values from the waveforms are overdriven in many cases by a front-end spike caused by gage overshoot. Gage overshoot occurs when the gage is excited by shock front frequencies near its resonant frequency. The peak pressure values tabulated in Appendix B are the author's best attempt at compensating for gage overshoot, and are subject to reexamination.

3.3 COMPARISON OF SQUARE TUNNEL DATA TO ROUND TUNNEL DATA

Comparison of data from square tunnel tests with data from round tunnel tests for similar yields and nominal entrance pressures requires use of a scaling parameter that will establish similitude between the different entrance geometries. The concept of an effective diameter was introduced during the 1981 and 1982 series, and was proposed as equal to \sqrt{A} , where A is the cross-sectional area of the tunnel opening. The use of \sqrt{A} as a scaling factor yields the dimensionless parameter X/\sqrt{A} , where X is the distance down the tunnel from the entranceway.

Figures 3.2-3.6 illustrate the comparison of peak pressure data from the 30 cm diameter round tunnel tests of the 1982 series with peak pressure data

from the 30 cm square tunnel tests of 1983. Pressures are plotted versus scaled distance, X/\sqrt{A} , for several yields (W) and entrance pressures (P_0). The plots indicate reasonable agreement in peak pressure at large scaled distances, where at small scaled distances the data scatter broadens due to uncertainties of the near entrance airblast peaks. However, a general trend of peak pressure attenuation with distance down the tunnel can be determined from the plots. An interesting variation in the two data sets is that peak pressures near the entranceway for the square tunnel tests tend to be higher than near entrance pressures for the round tunnel tests.

As an alternative to \sqrt{A} , the diagonal $\sqrt{B^2+B^2}$ was used as the geometrical scaling parameter for the square tunnel data, where B is the width of the entrance. Figures 3.7-3.11 illustrate the comparison of peak pressure data from square tunnels, scaled by $\sqrt{B^2+B^2}$, with round tunnel pressure data, scaled by \sqrt{A} . The data tend to agree better when scaled by this method, especially at large scaled distances, although near entrance pressures are still widely scattered.

3.4 COMPARISON OF 30 cm AND 15 cm SQUARE TUNNEL DATA

Cube-root scaling indicates that similitude should exist between the 30 cm and 15 cm tunnels for charge weights of 907 g and 113 g, respectively, at a given entrance pressure. All linear dimensions and times should scale by the factor $\left(\frac{907}{113}\right)^{1/3} = 2$, and peak pressure values should remain the same for similar scaled distances. Figures 3.12-3.14 illustrate the comparison of peak pressure data for the 30 cm and 15 cm square tunnels as a function of scaled distance X/B . Again, data agree well at large values of X/B , but tend to scatter significantly at small values of X/B . Use of the diagonal $\sqrt{B^2+B^2}$ as a scaling parameter would not change the relationship since the parameter for

both tunnels would differ by the factor $\sqrt{2}$.

Figure 3.15 shows the relationship of peak pressure data from the 15 cm square tunnel, $W = 113$ g, with that of the 30 cm round tunnel test from 1982, $W = 907$ g. Scaled distance is shown as $X/\sqrt{B^2+B^2}$ for the square tunnel and X/\sqrt{A} for the round tunnel.

3.5 EFFECTS OF ENTRANCE SHIELD AND ABRUPT EXPANSION

The effects of the entrance shield on the penetrating airblast wave can best be observed from the individual waveforms for each test. In general, the reflected wave from the entrance shield arrives shortly after the initial pulse, with amplitude at or near that of the initial pulse.

The effects of the abrupt expansion entranceway on airblast penetration are best explained from the individual waveforms, also. Waveforms from measurement locations immediately after the expansion indicate a complex pattern of peaks and reflections similar to those observed in near entrance waveforms. Several tunnel diameters from the expansion, the waveforms tend to stabilize and attenuate with distance at a higher rate than airblast in the regular, non-expansion tunnels of equal width. This is illustrated in Figures 3.16-3.19 for several entrance pressures. Peak pressures are plotted versus scaled distance X/B . The reduction in pressure at large scaled distances would appear to be a result of energy dissipation by the expansion.

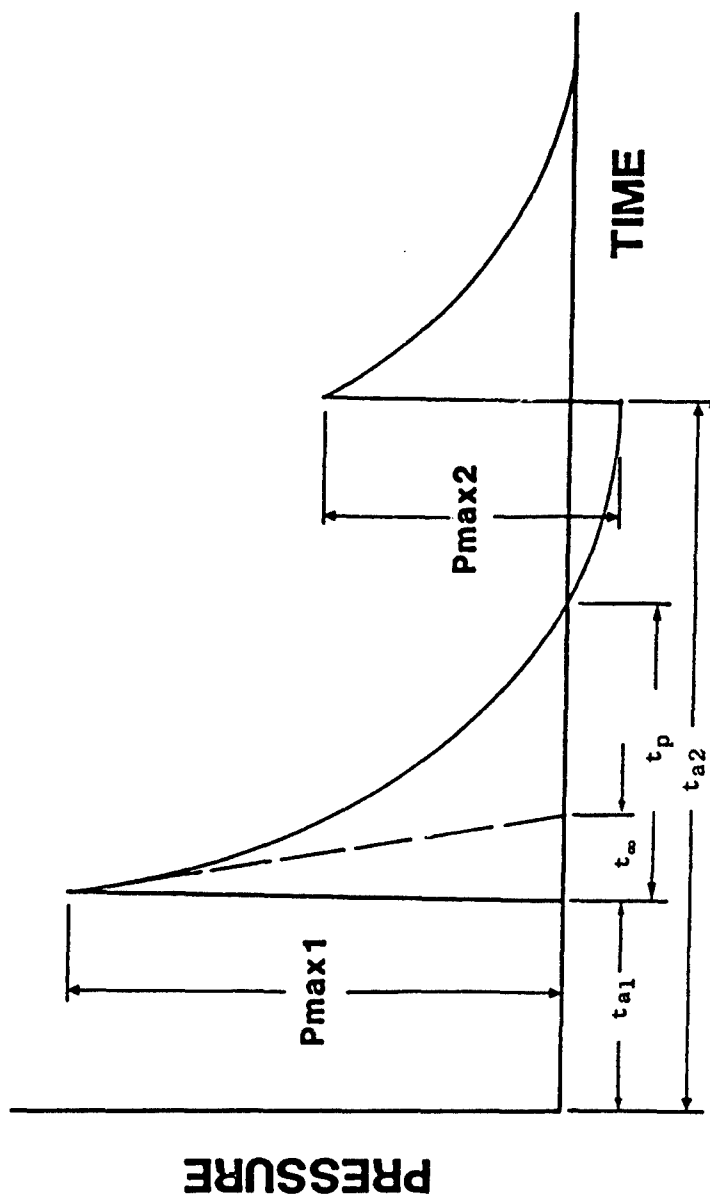
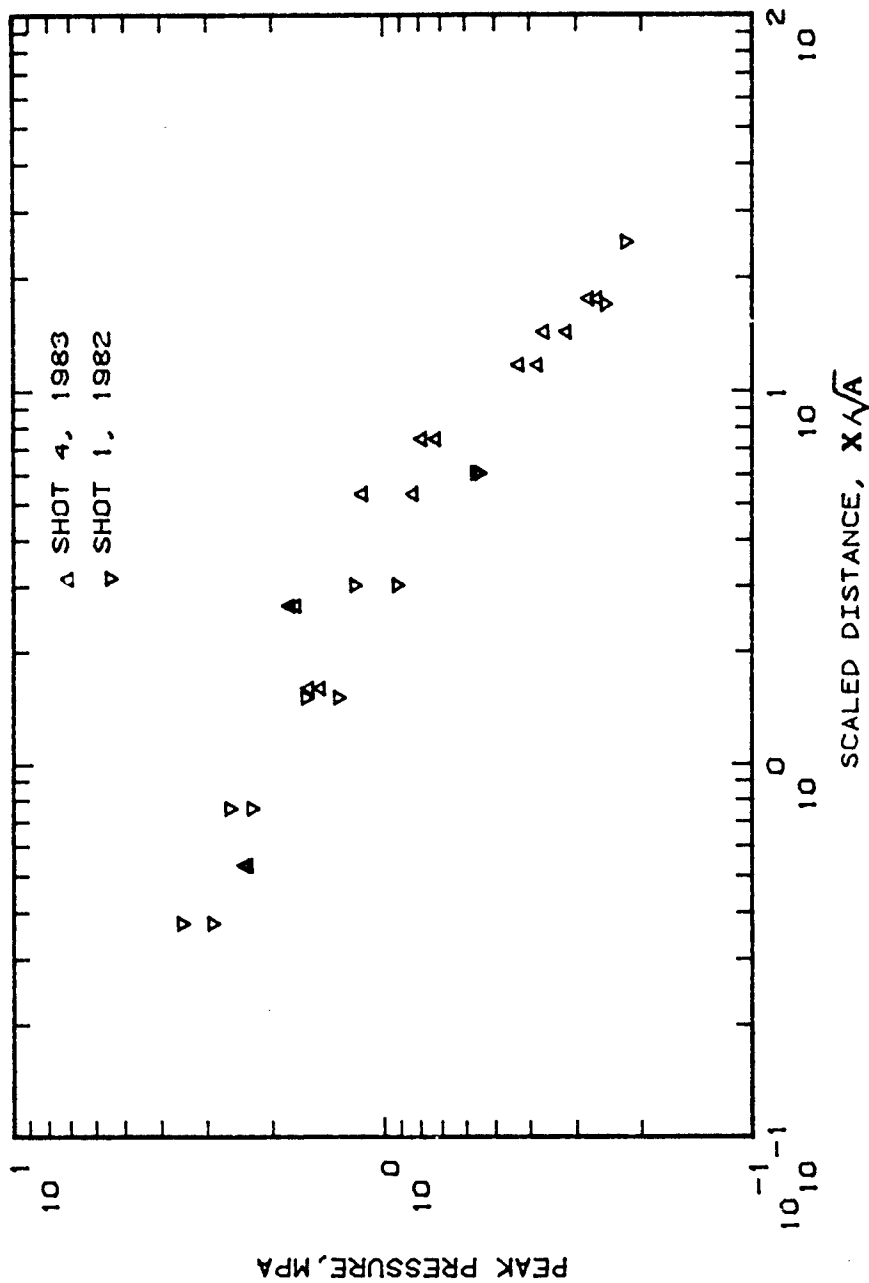


Figure 3.1 Definition of Tabulated Blast Parameters



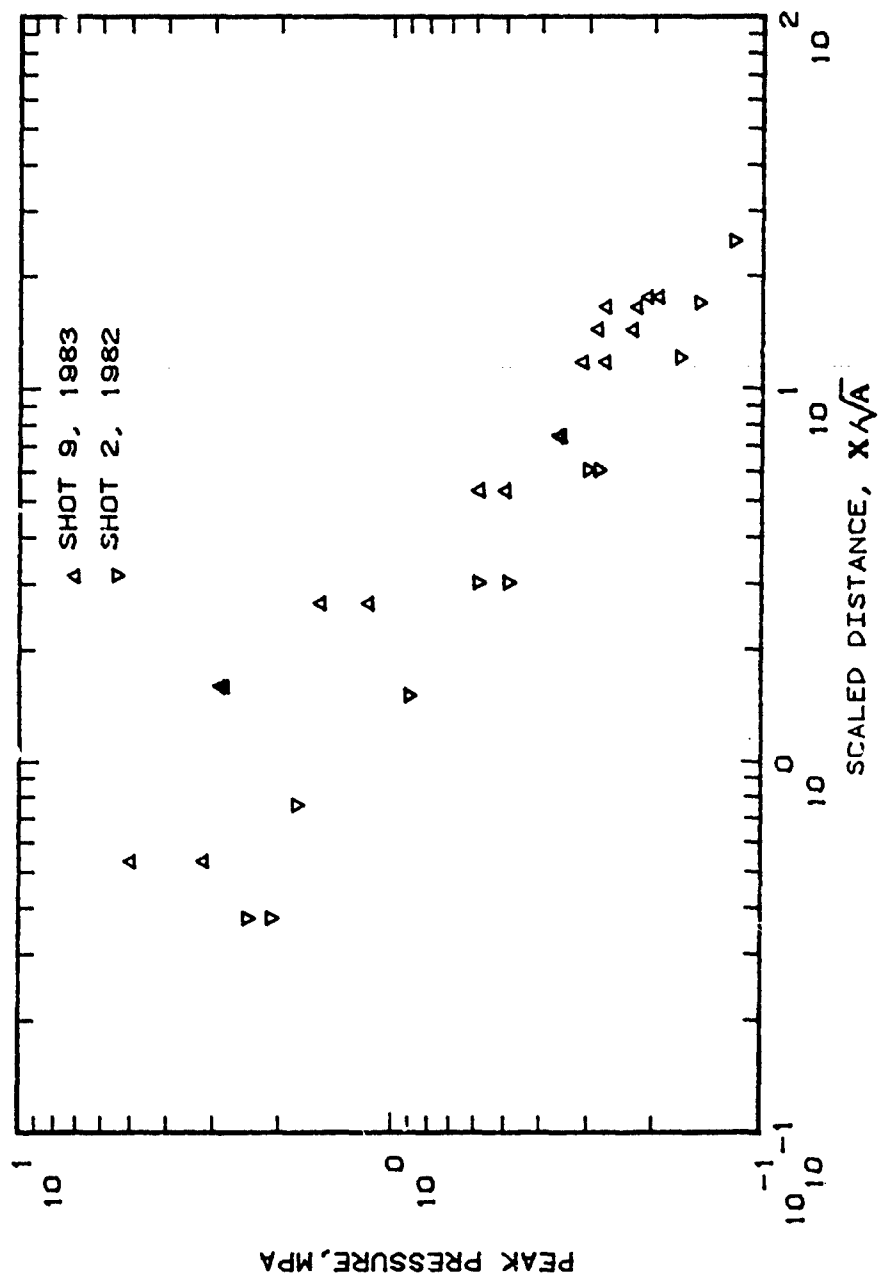
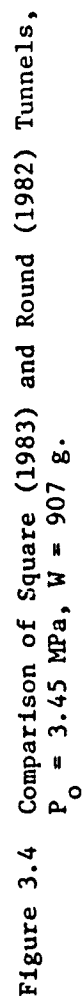


Figure 3.3 Comparison of Square (1983) and Round (1982) Tunnels,
 $P_0 = 3.45 \text{ MPa}$, $W = 113 \text{ g}$.



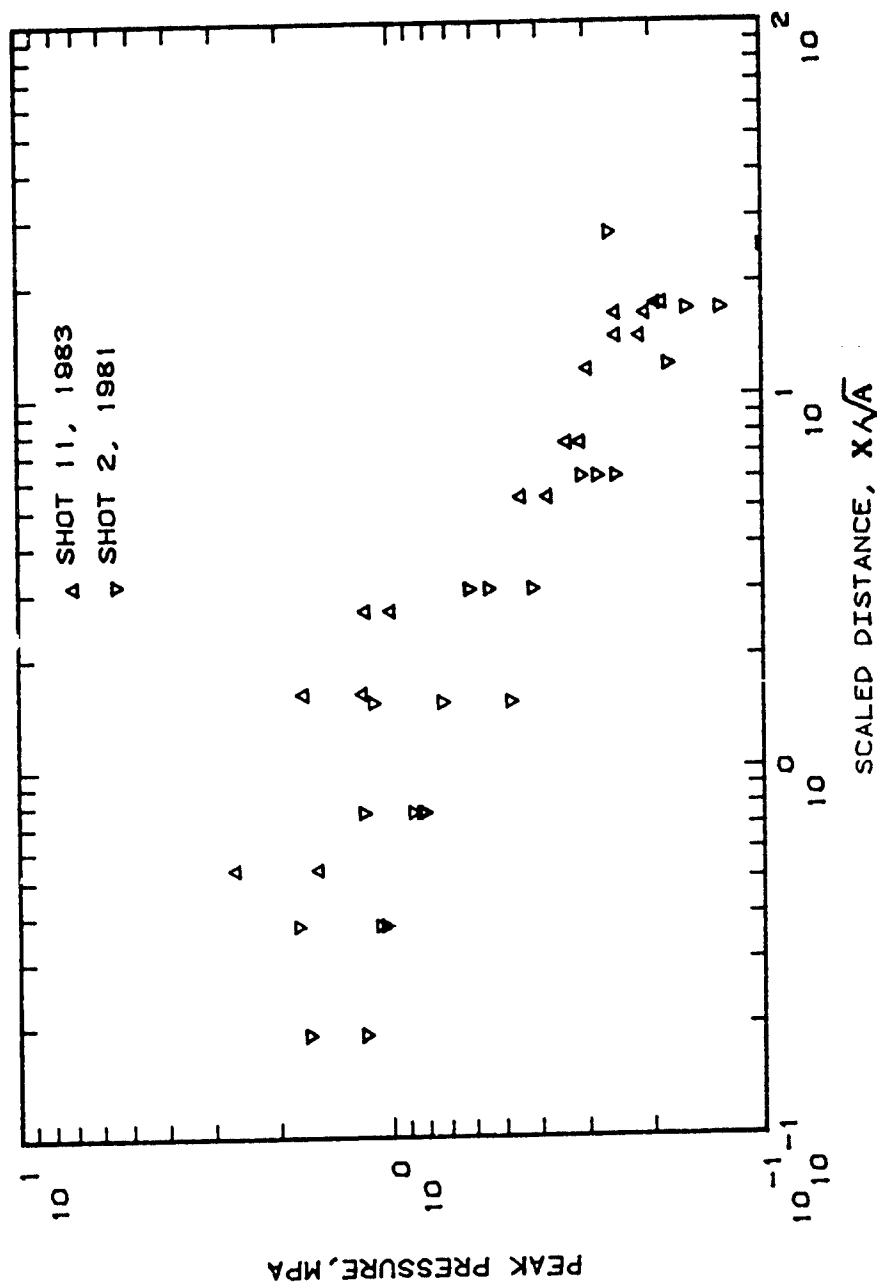


Figure 3.5 Comparison of Square (1983) and Round (1981) Tunnels,
 $P_0 = 1.38 \text{ MPa}$, $W = 340 \text{ g}$.

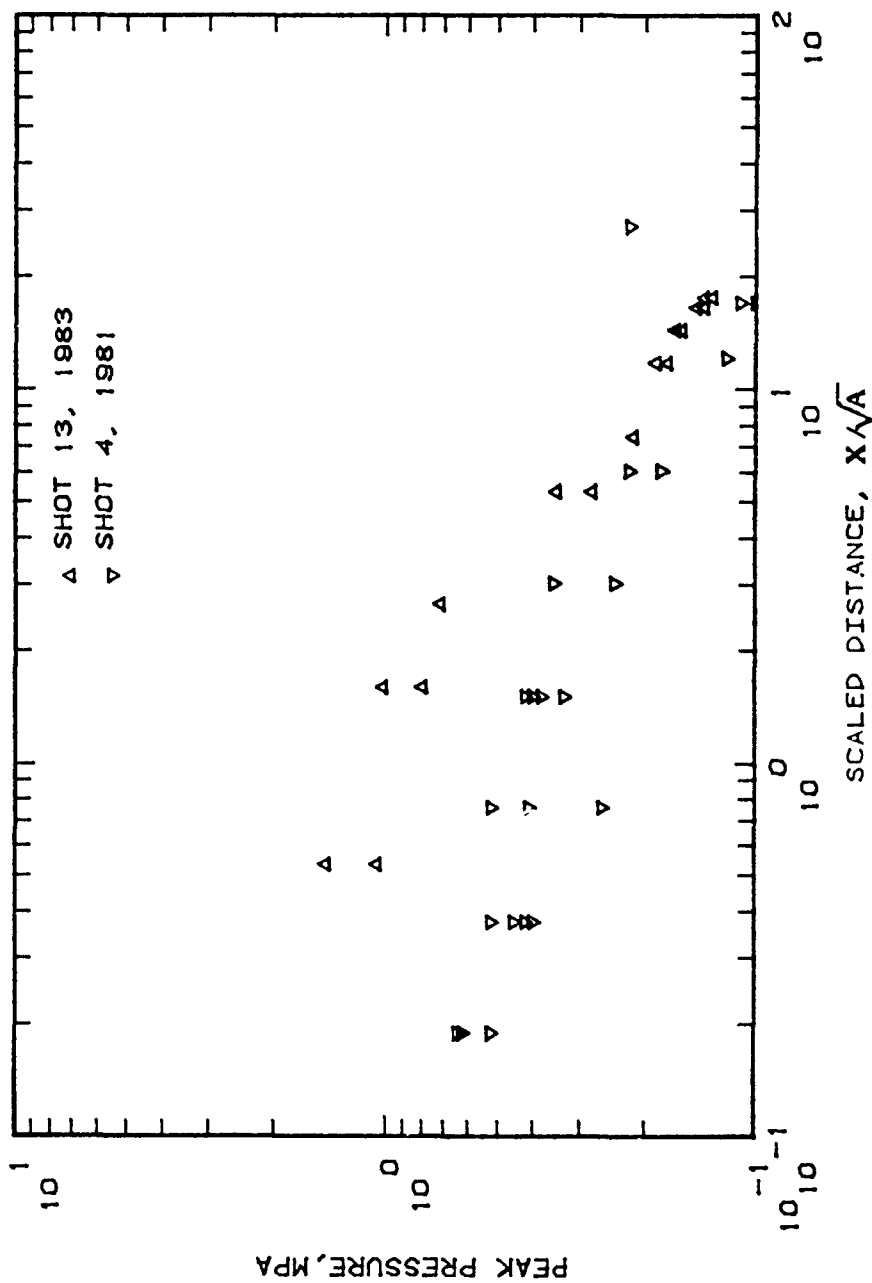


Figure 3.6 Comparison of Square (1983) and Round (1981) Tunnels,
 $P_o = 0.69 \text{ MPa}$, $W = 340 \text{ g}$.

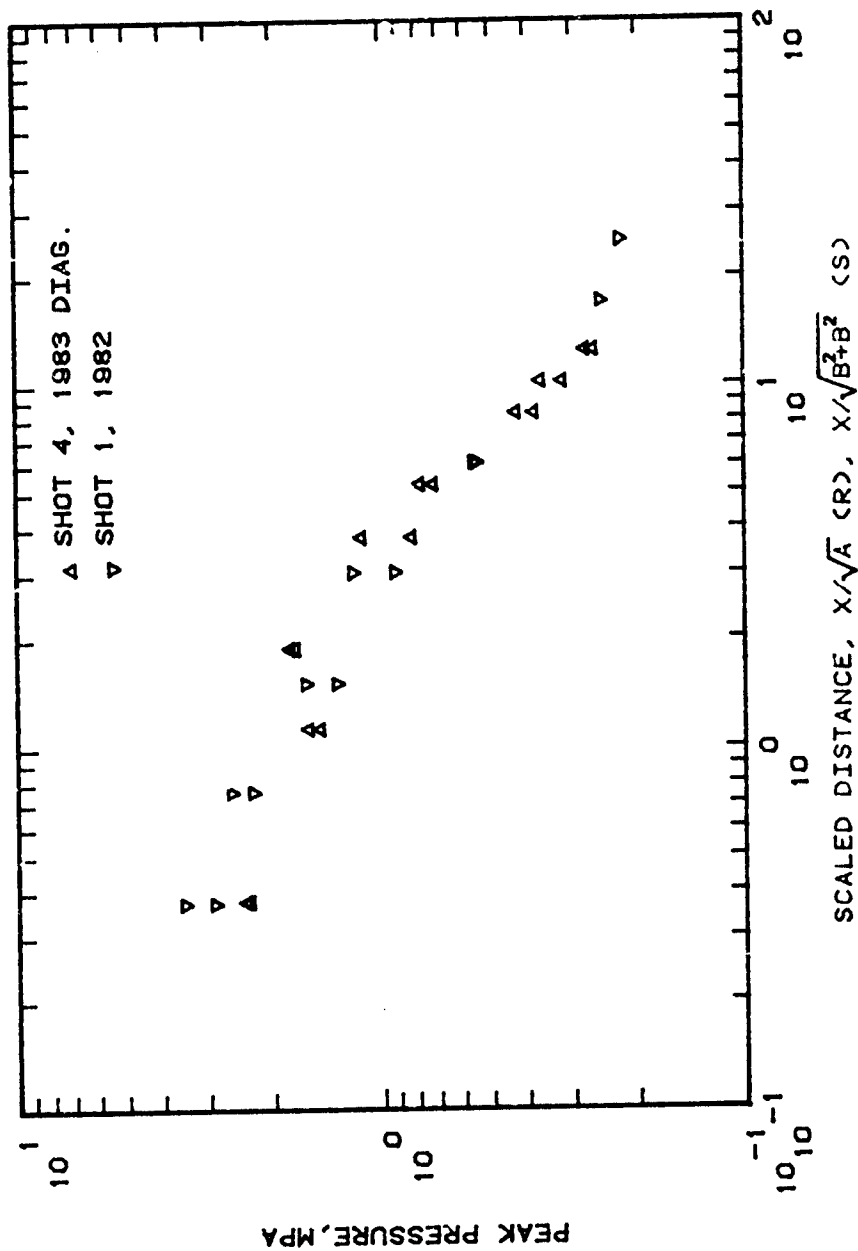


Figure 3.7 Comparison of Diagonal Scaled Square Tunnel with \sqrt{A}
 Scaled Round Tunnel, $P_0 = 3.45$ MPa, $W_0 = 340$ g.

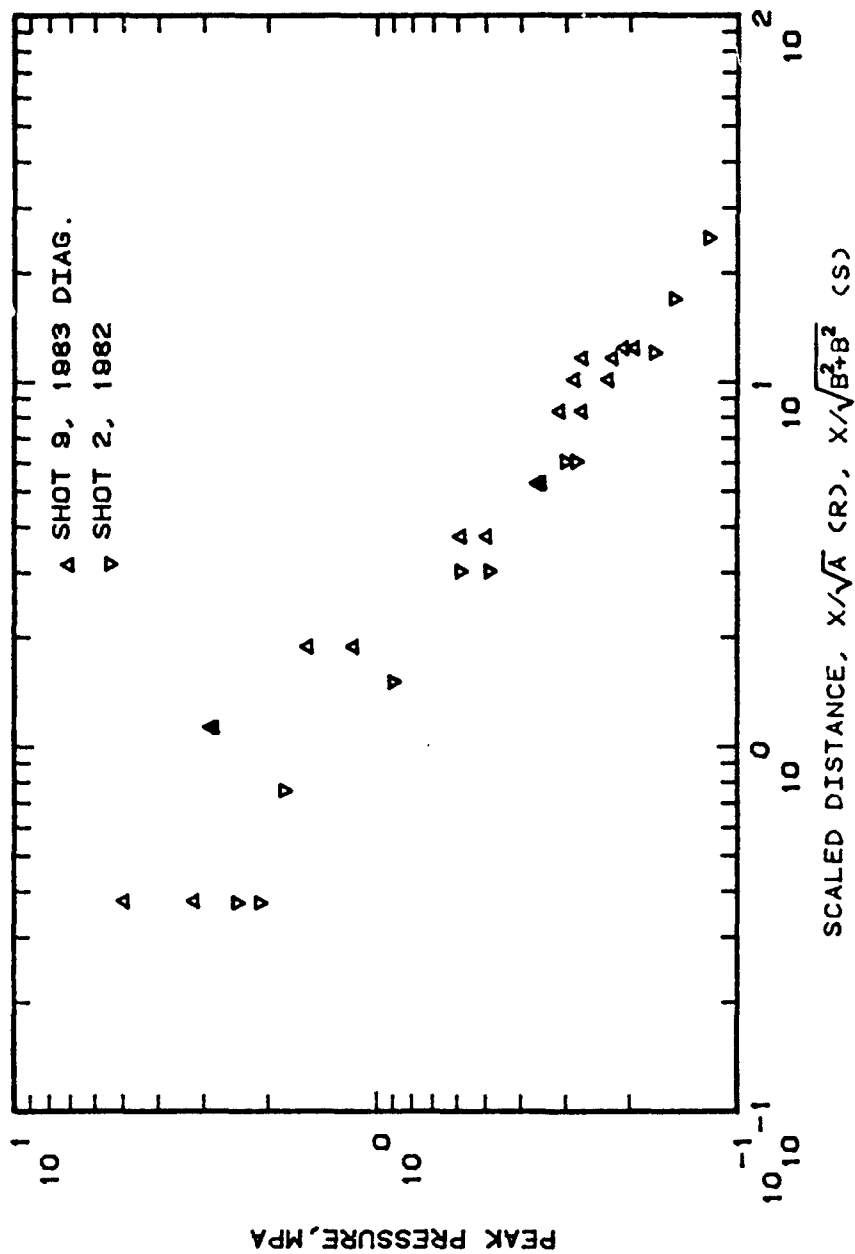


Figure 3.8 Comparison of Diagonal Scaled Square Tunnel with \sqrt{A} Scaled Round Tunnel, $P_0 = 3.45$ MPa, $W = 113$ g.

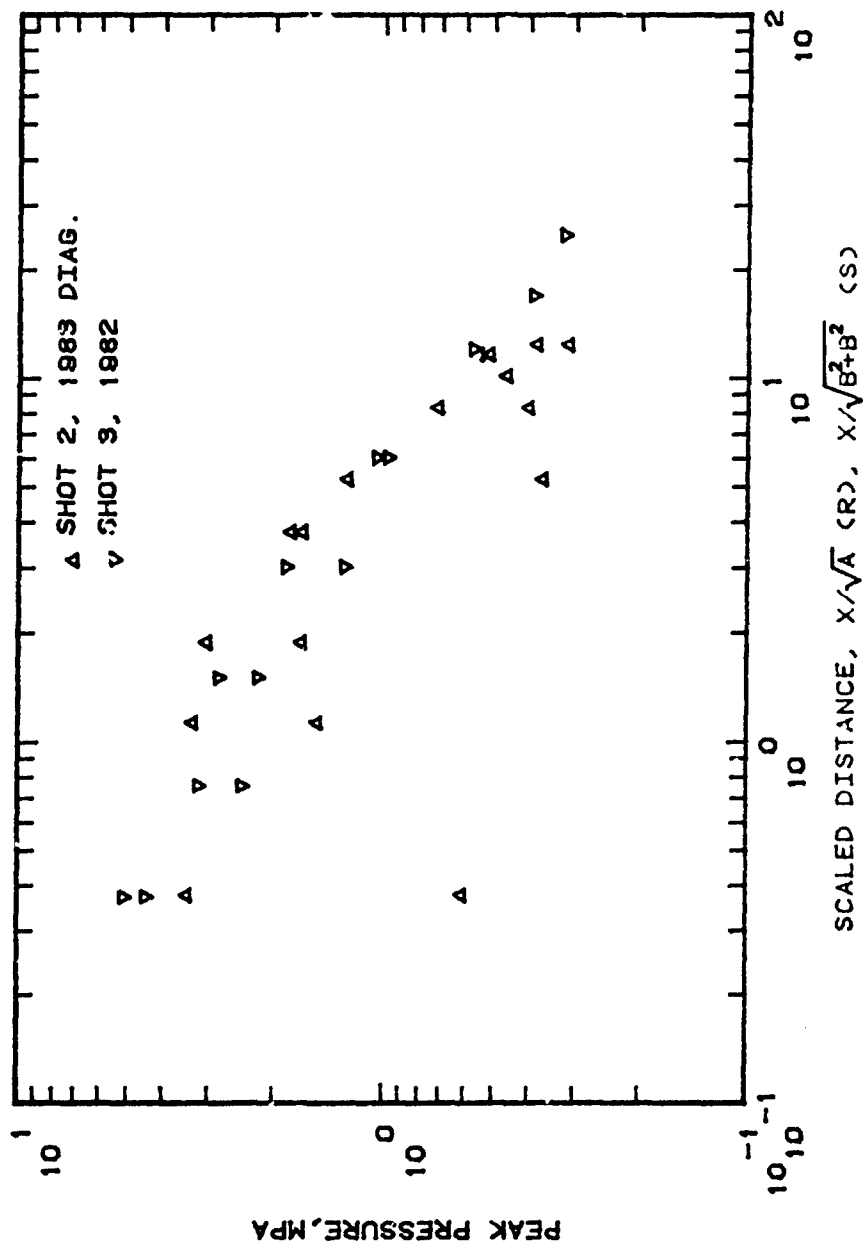


Figure 3.9 Comparison of Diagonal Scaled Square Tunnel with \sqrt{A}
Scaled Round Tunnel, $P_0 = 3.45$ MPa, $W = 907$ g.

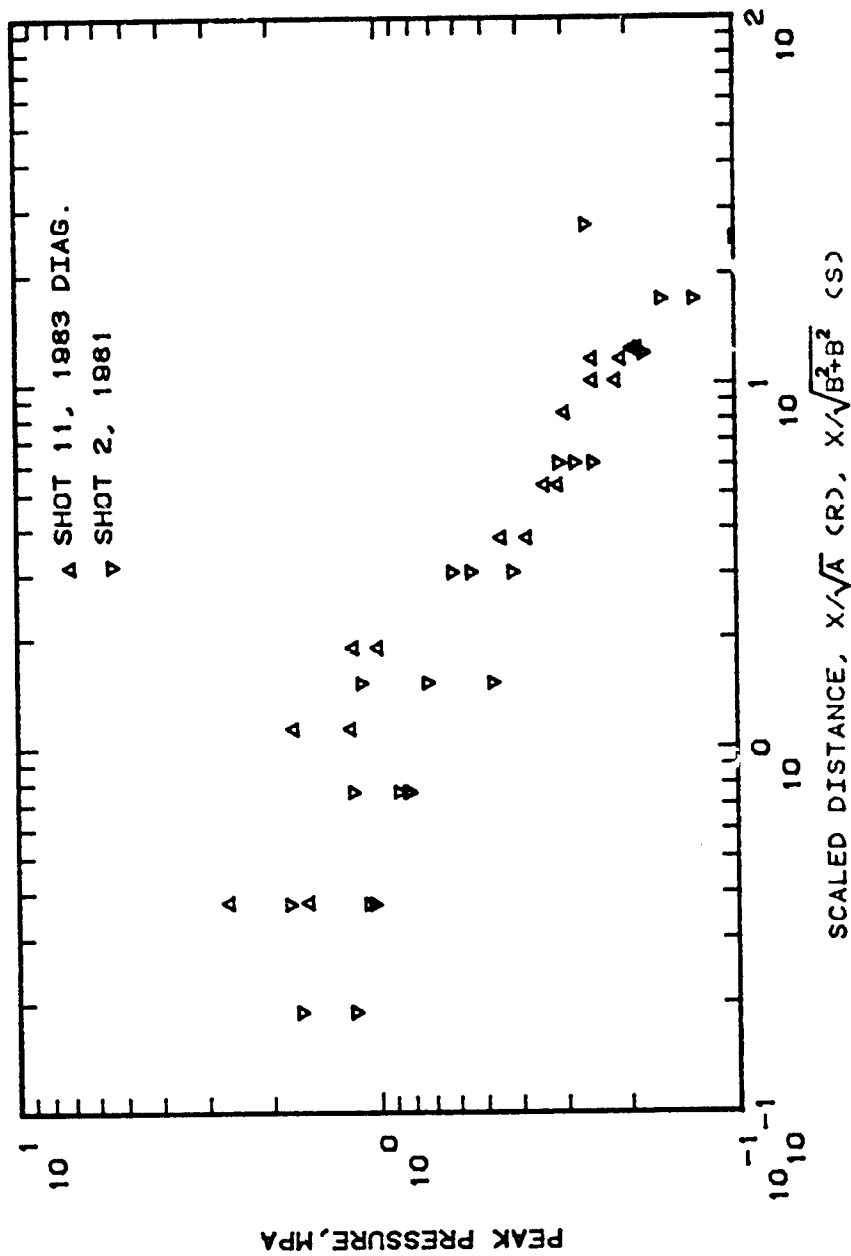


Figure 3.10 Comparison of Diagonal Scaled Square Tunnel with \sqrt{A}
 Scaled Round Tunnel, $P_0 = 1.38$ MPa, $W = 340$ g.

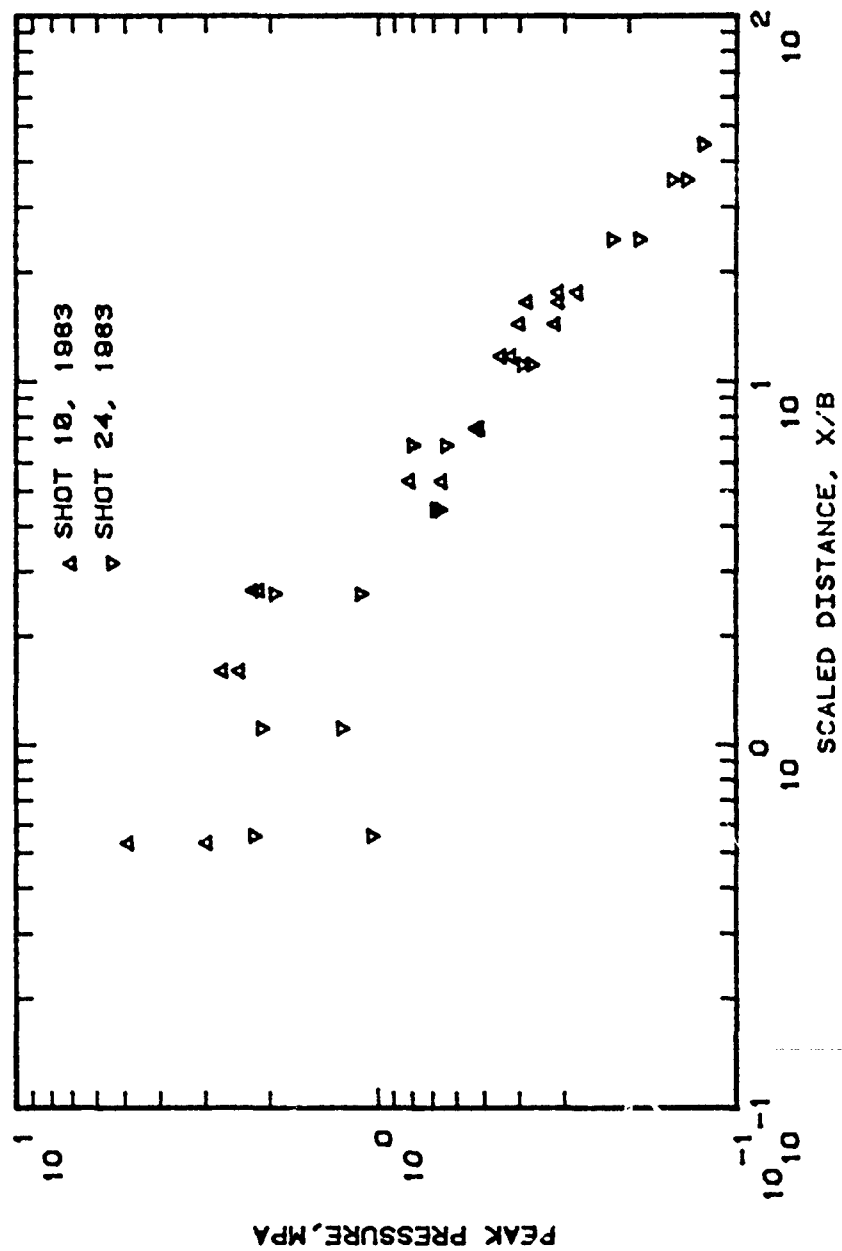


Figure 3.12 Comparison of 30 cm and 15 cm square tunnels, $P_o = 1.38$ MPa.

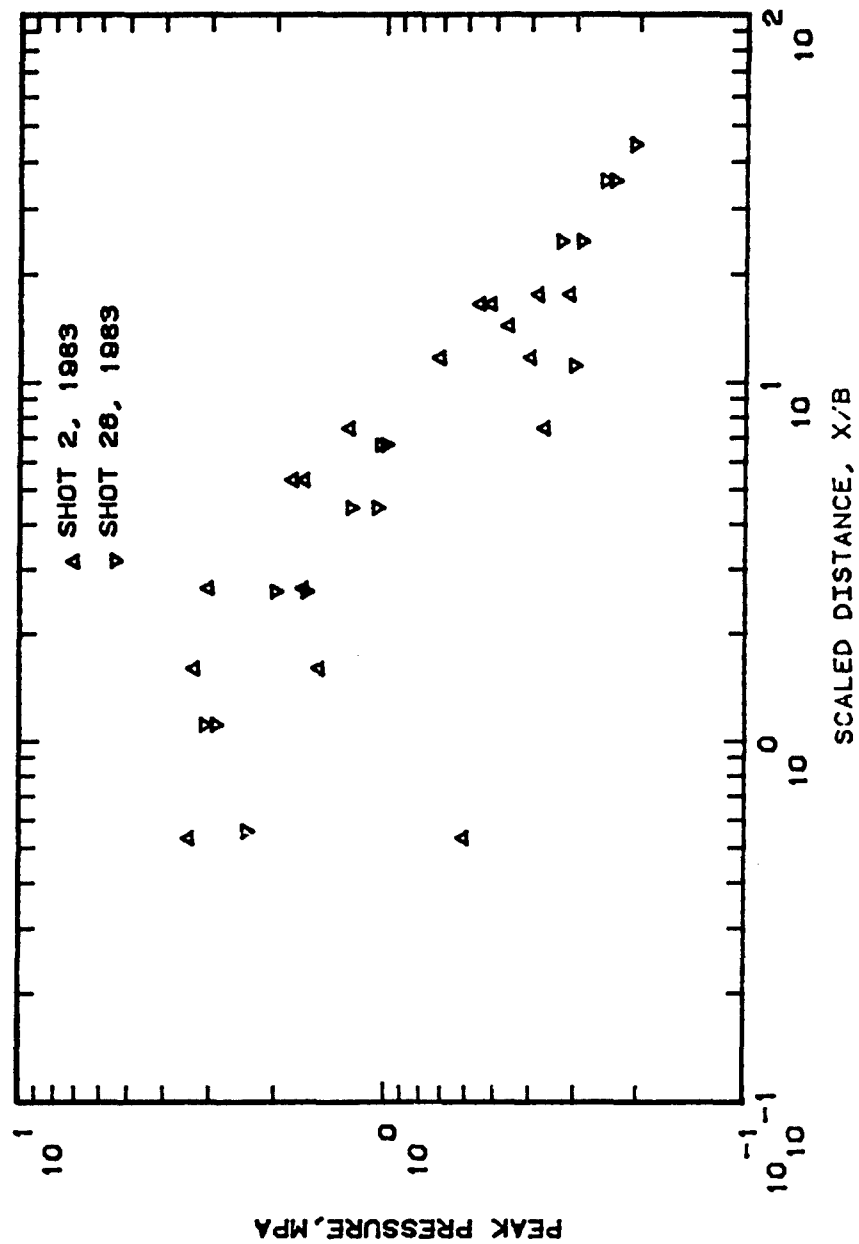


Figure 3.13 Comparison of 30 cm and 15 cm square tunnels, $P_0 = 3.45$ MPa.

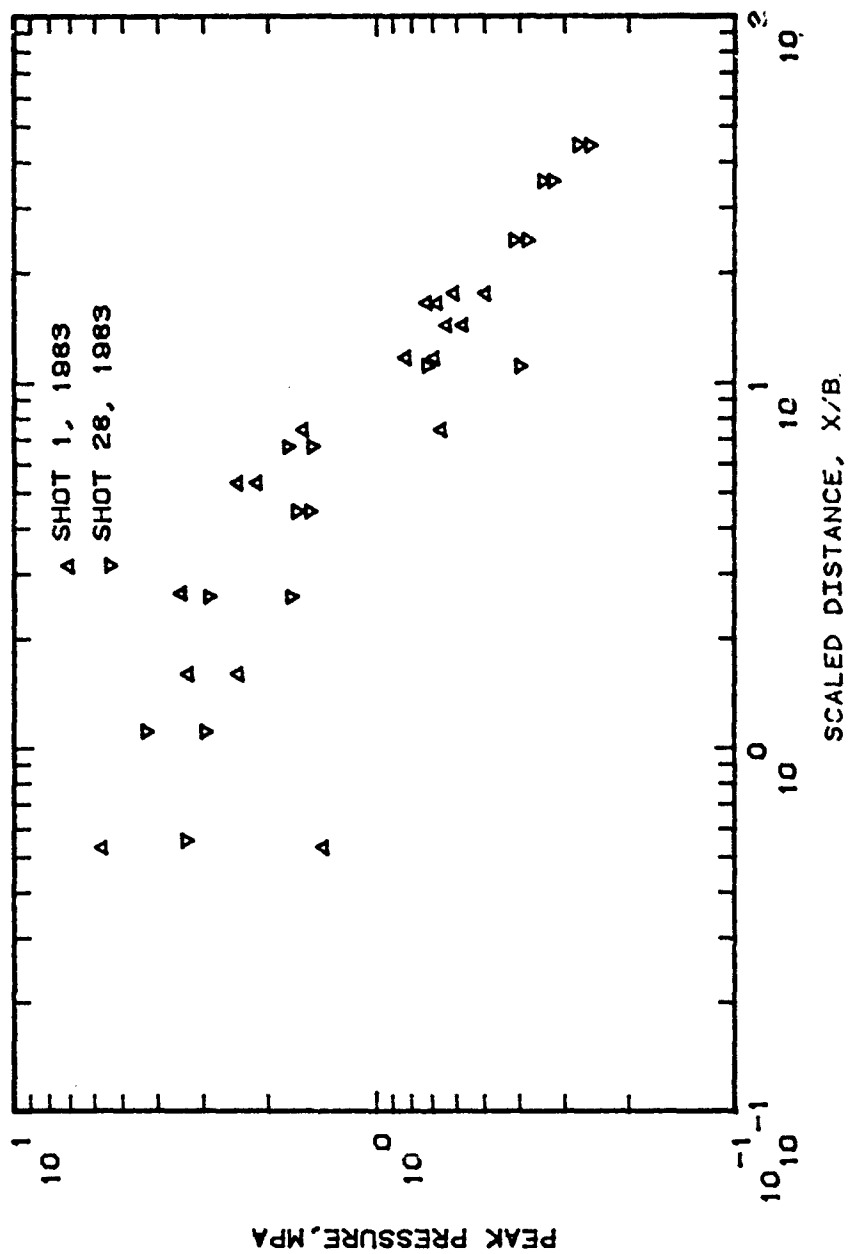


Figure 3.14 Comparison of 30 cm and 15 cm square tunnels, $P_0 = 6.89$ MPa.

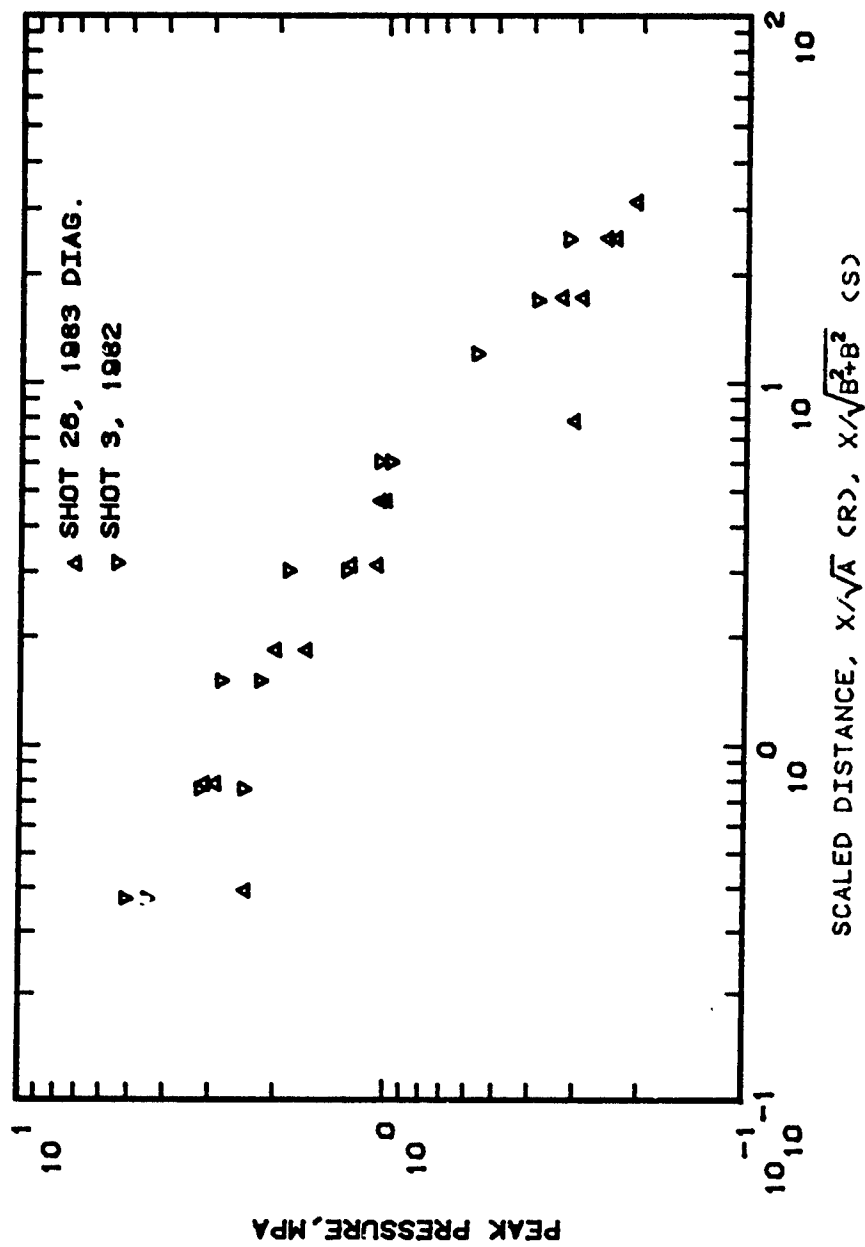


Figure 3.15 Comparison of 15 cm square tunnel and 30 cm round tunnel, $P_0 = 3.45$ MPa.

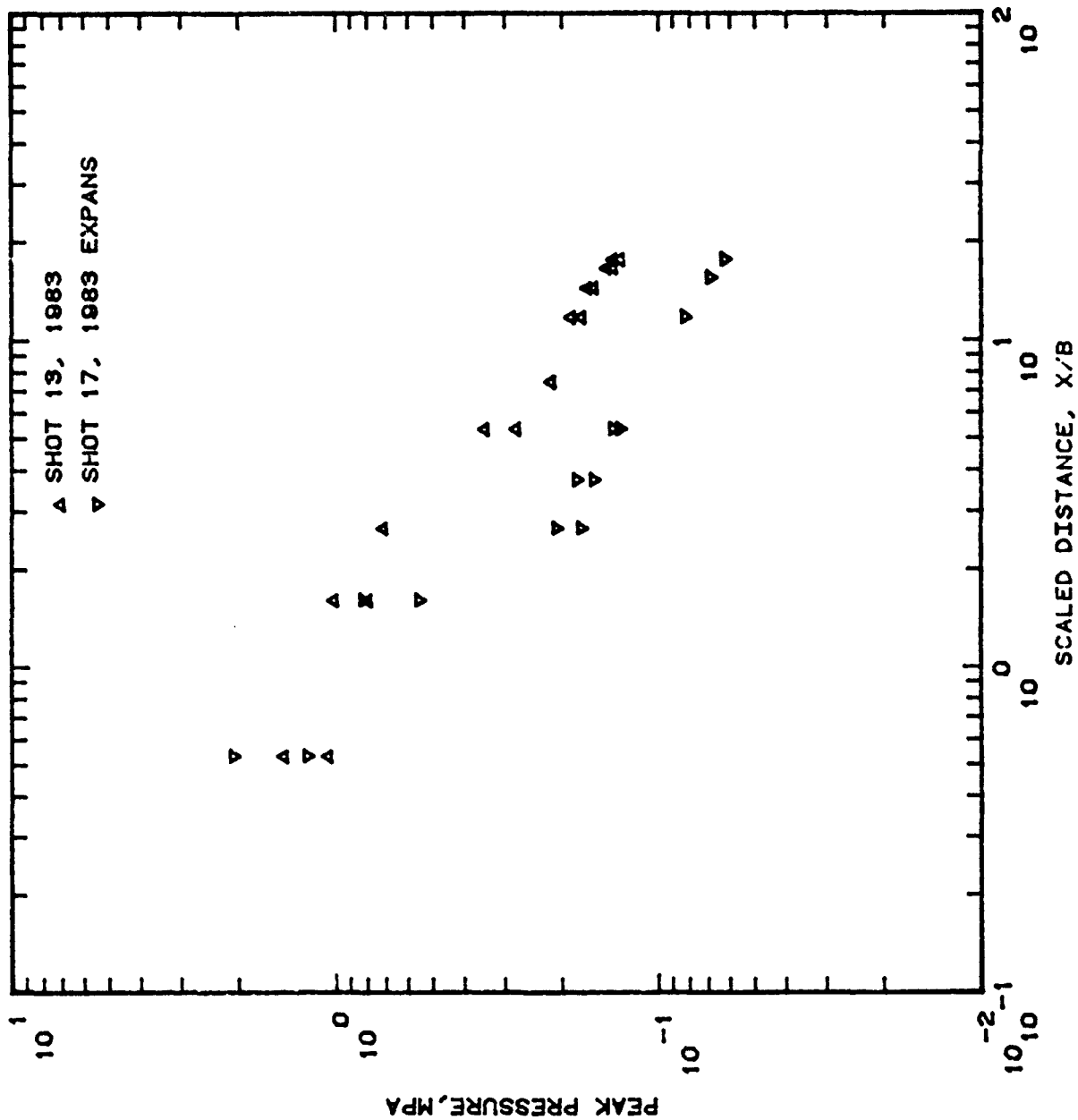


Figure 3.16 Effects of 15 cm to 30 cm expansion, $P_0 = 0.69$ MPa, $W = 340$ g.

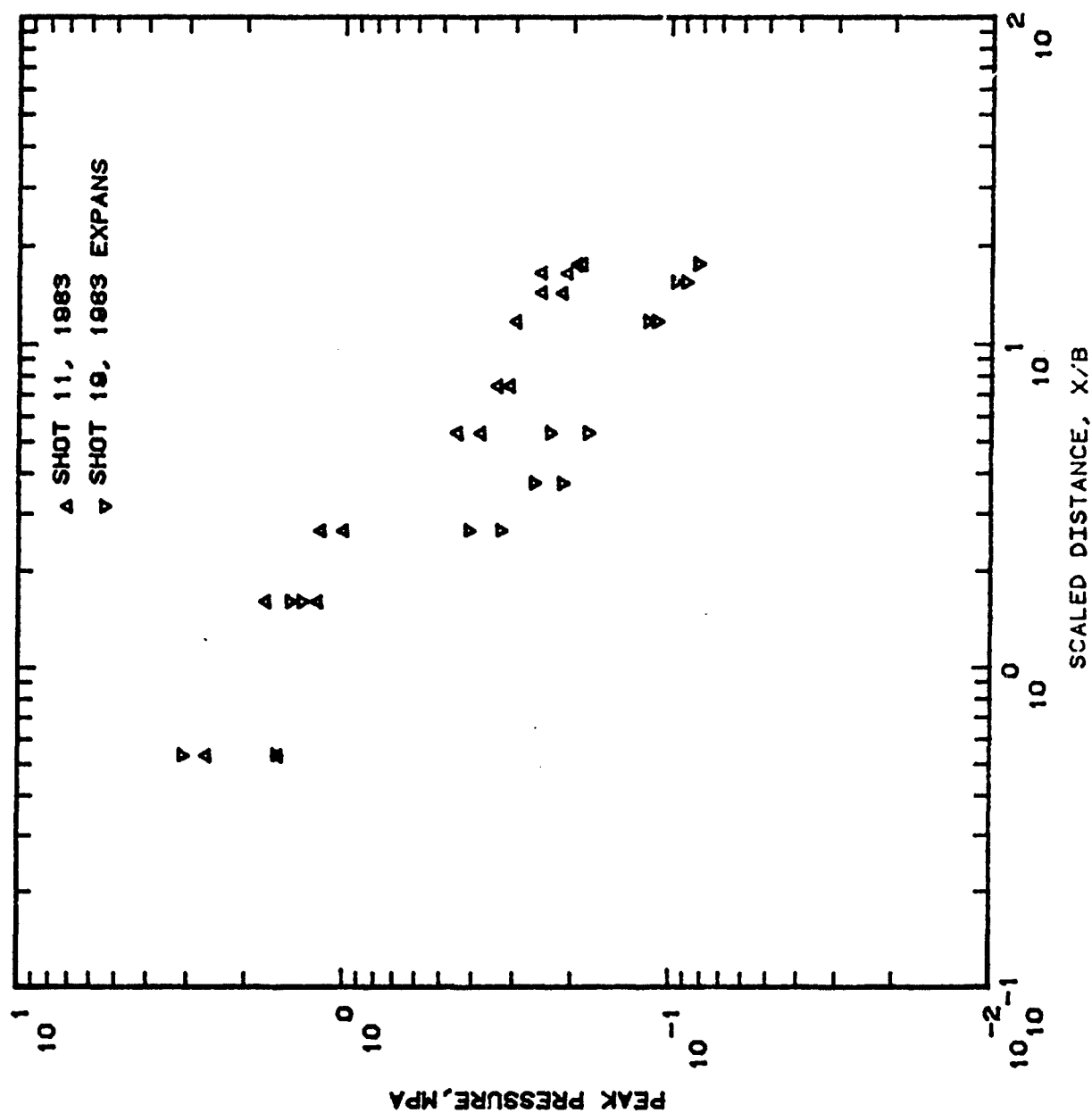


Figure 3.17 Effects of 15 cm to 30 cm expansion, $P_0 = 1.38$ MPa, $W = 340$ g.

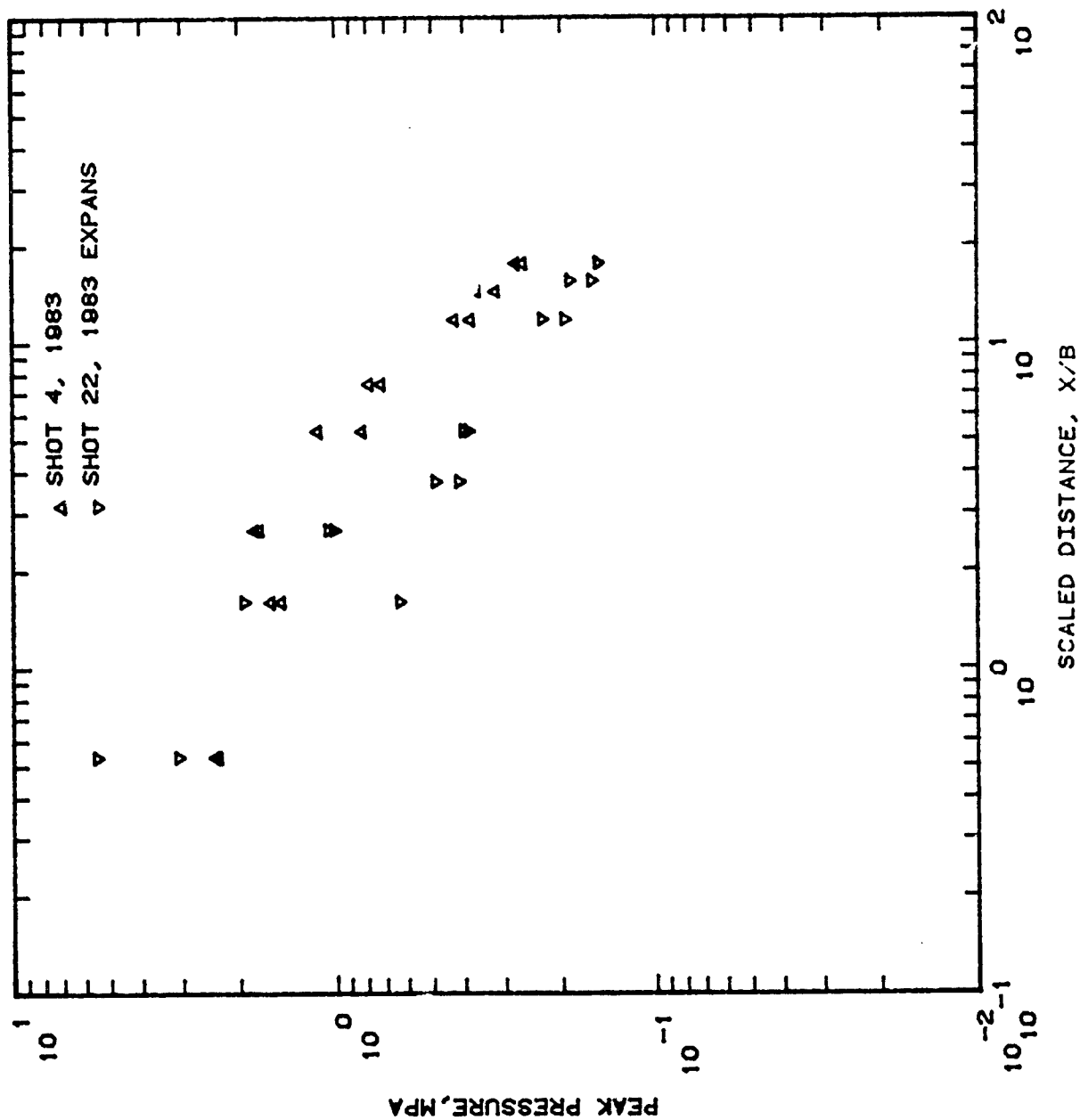


Figure 3.18 Effects of 15 cm to 30 cm expansion, $P_0 = 3.45$ MPa, $W = 340$ g.

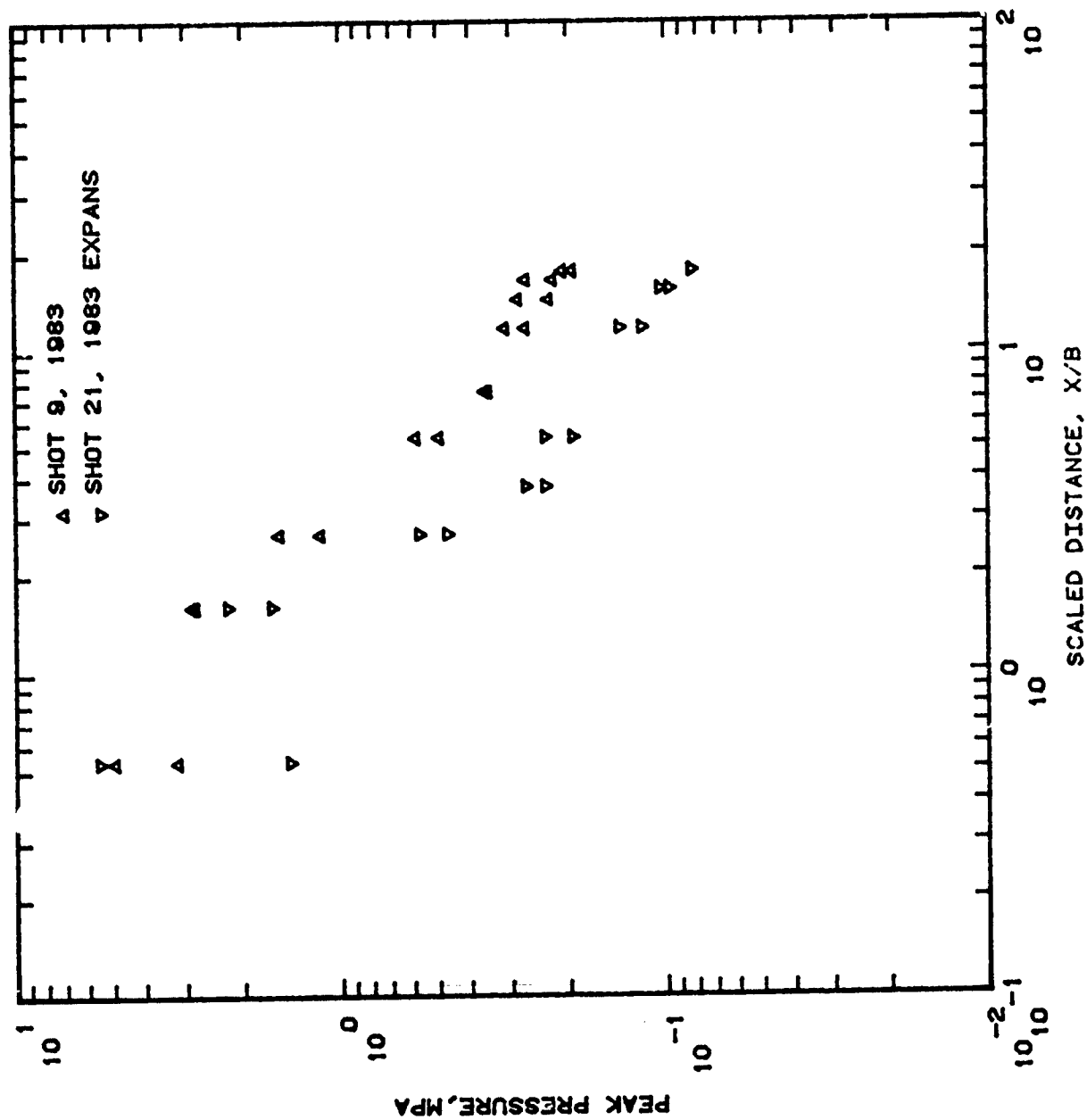


Figure 3.19 Effects of 15 cm to 30 cm expansion, $P_0 = 3.45$ MPa, $W = 113$ g.

CHAPTER 4

CONCLUSIONS

Conclusions developed from the investigation results are as follows:

1. Airblast shock fronts immediately following entranceways and abrupt expansions in tunnel diameter are complex due to reflections and diffractions. Peaks tend to stabilize at 5 to 8 tunnel diameters from the entrance.
2. Square tunnel peak pressure data tend to agree with \sqrt{A} scaled round tunnel peak pressure data better when scaled by the cross-section diagonal $\sqrt{B^2+B^2}$ than when scaled by \sqrt{A} for a given entrance pressure, charge weight, and $D = B$. Pressure values at large scaled distances from the entrance are more consistent and attenuation trends are readily determined.
3. Airblast shocks reflected from entrance shields for side-on detonations tend to further complicate the blast pattern near the entrance with peaks of amplitude at or near that of the initial pulses.
4. Airblast attenuation rates following abrupt expansions from small to large tunnels tend to be greater than rates observed for tunnels of similar large dimensions but without expansions.

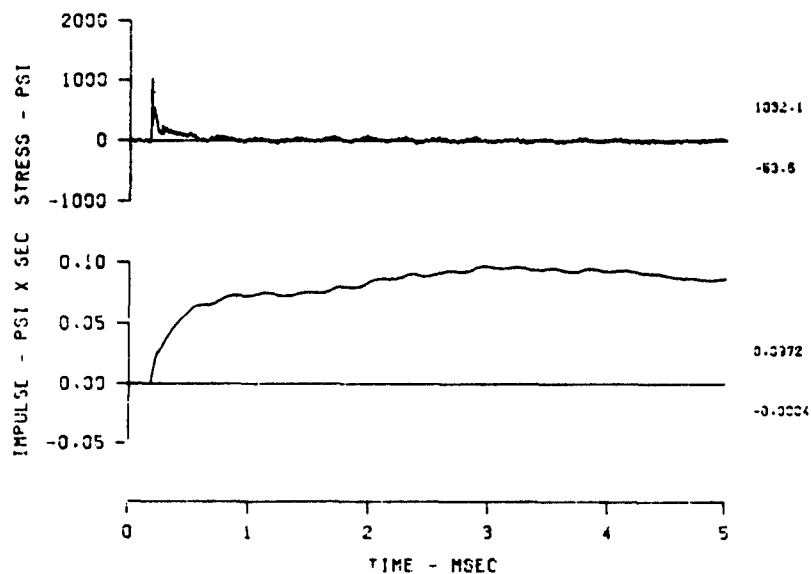
REFERENCES

1. Kriebel, A. R., "Airblast in Tunnels and Chambers," Nuclear Weapons Blast Phenomena, DASA 1200, Volume II, Supplement 1, Defense Nuclear Agency, 1972.
2. Coulter, G. A., "Attenuation of Peaked Air Shock Waves in Smooth Tunnels," BRL MR-1809, U. S. Army Ballistic Research Laboratories, 1966.
3. Itschner, D. and Anet, B., "Entry and Attenuation of Shock Waves in Tunnels," Proceedings Fifth International Symposium on Military Applications of Blast Simulation, Stockholm, 1977.
4. Gurke, G. and Scheklinski-Gluck, G., "An Investigation of Blastwave Penetration into a Tunnel Entrance," Report E 7/90, Ernst-Mach-Institute der Fraunhofer-Gesellschaft, Friburg, Germany, 1980.

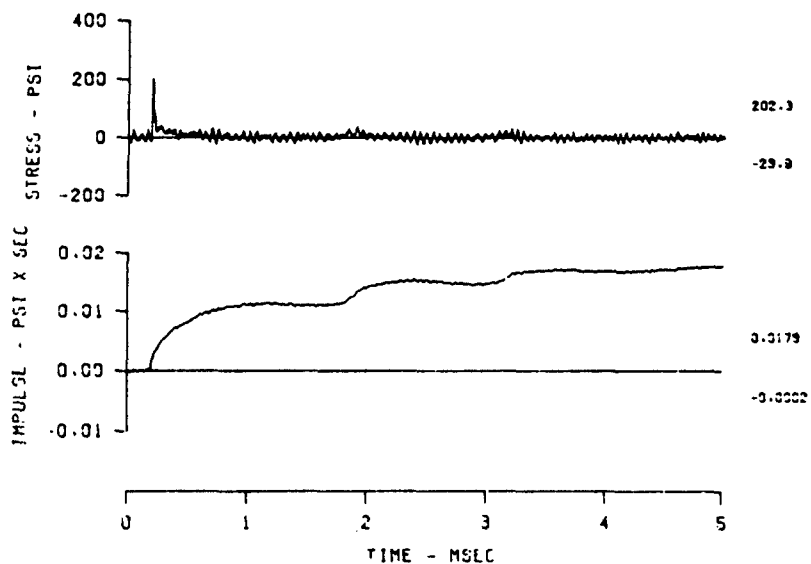
APPENDIX A

AIRBLAST PRESSURE-TIME
AND IMPULSE-TIME HISTORIES

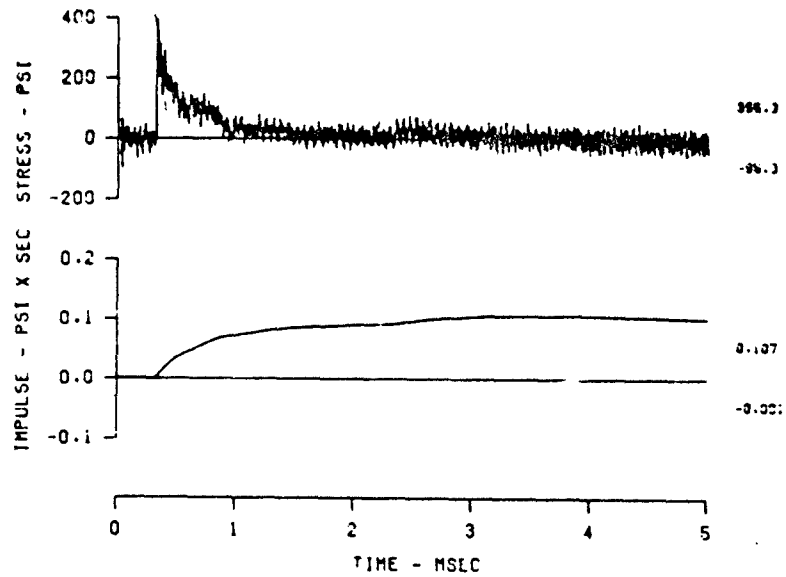
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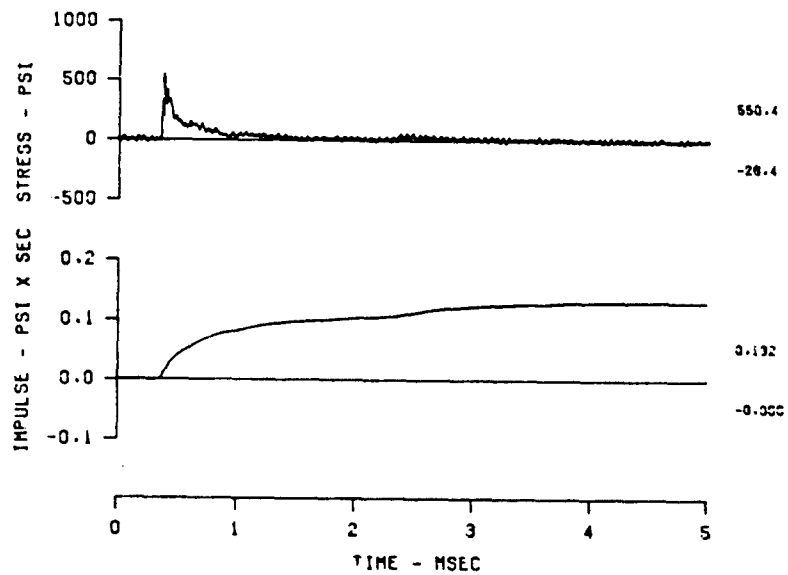
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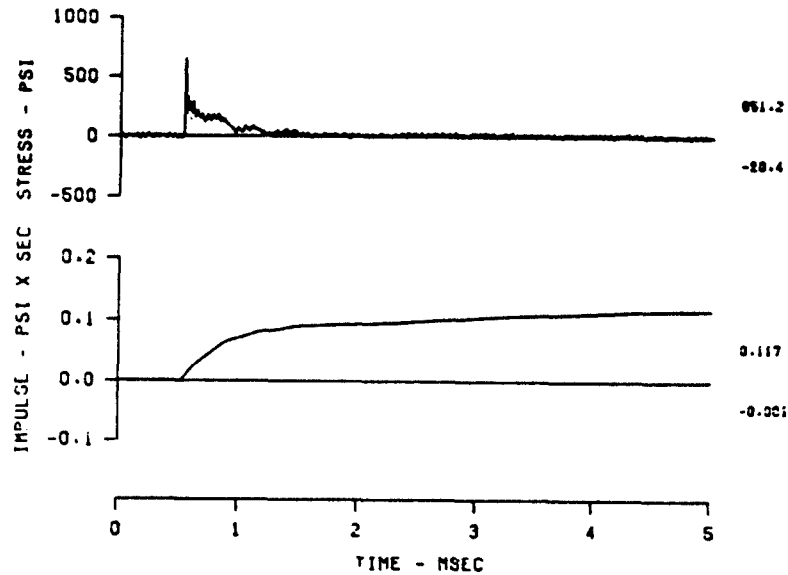
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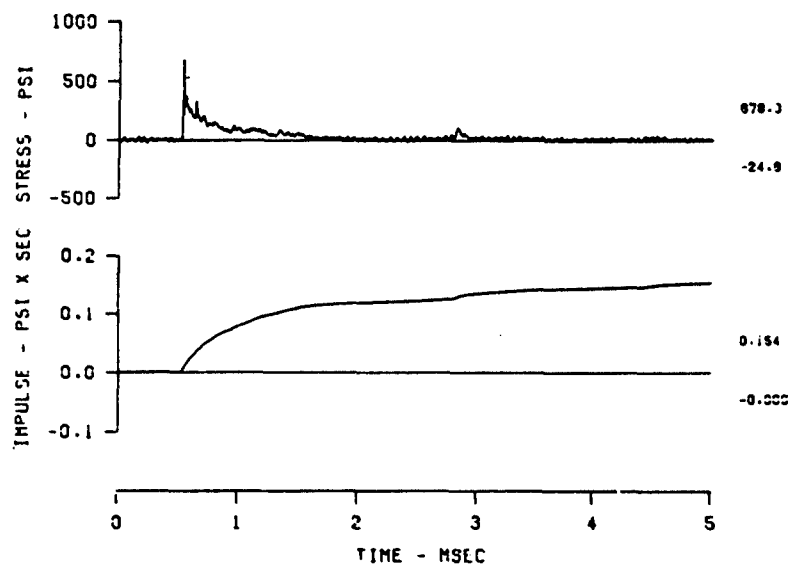
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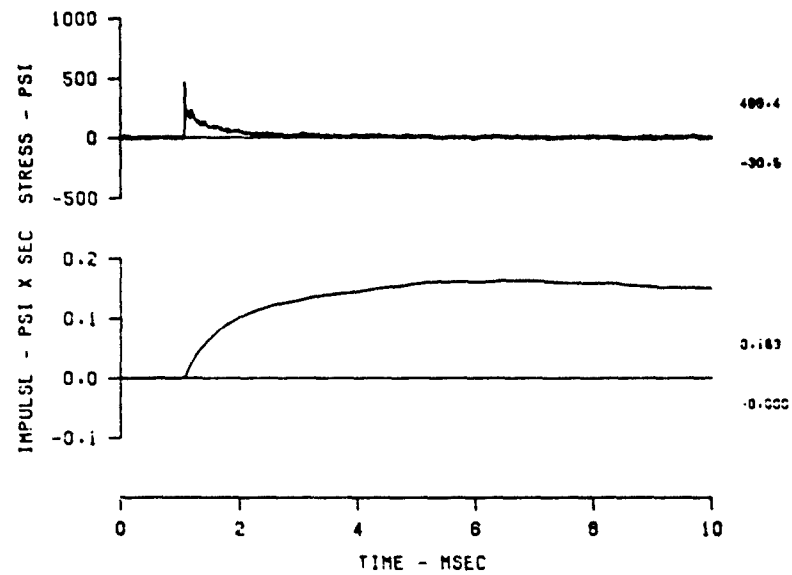
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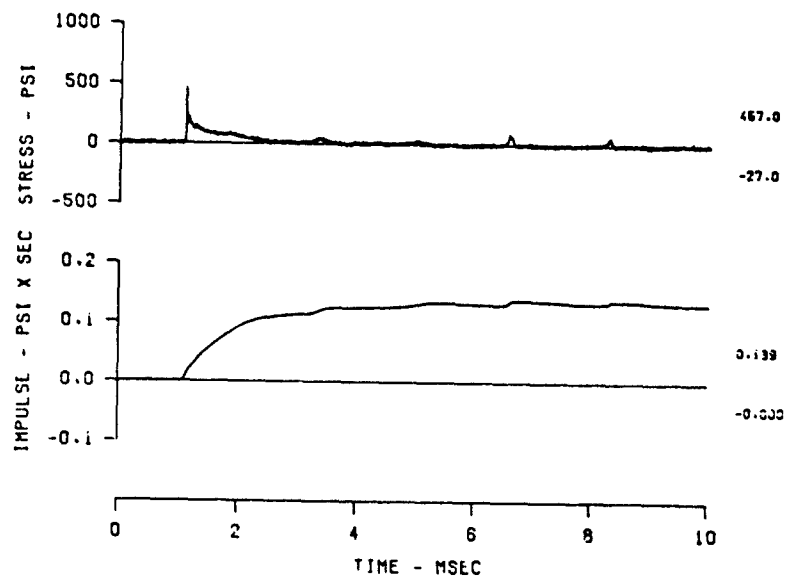
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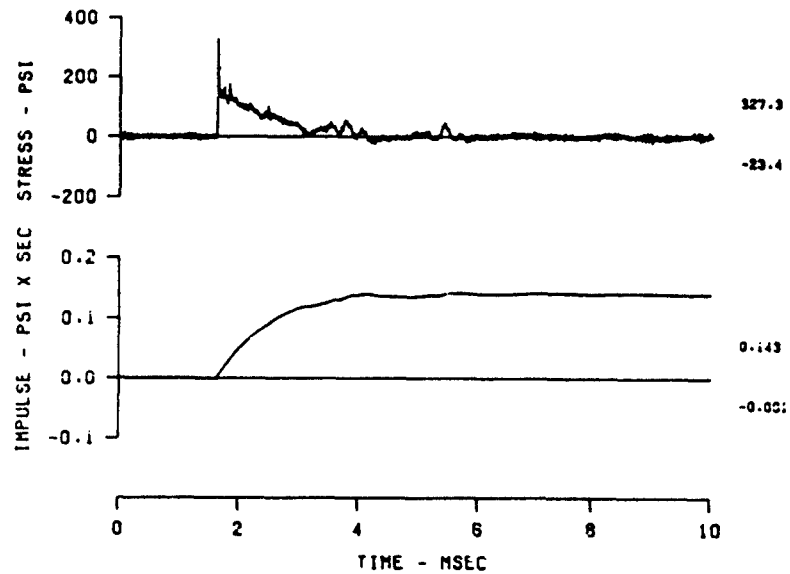
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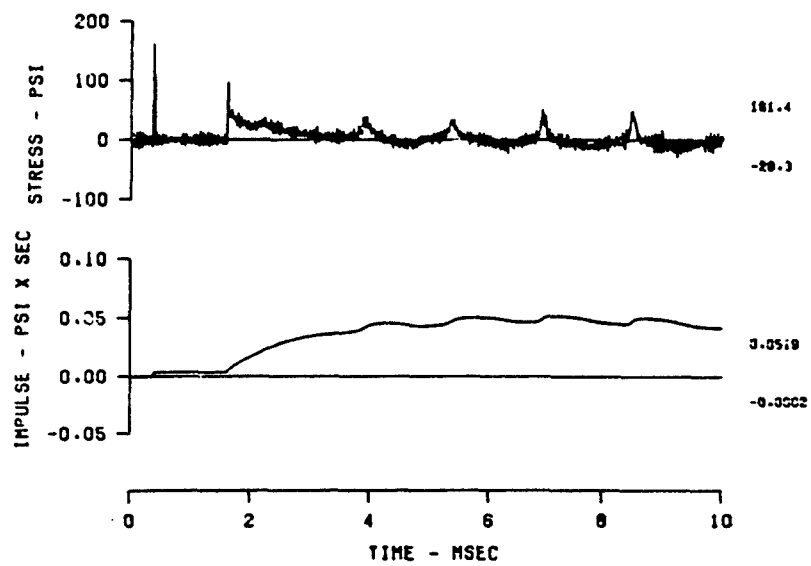
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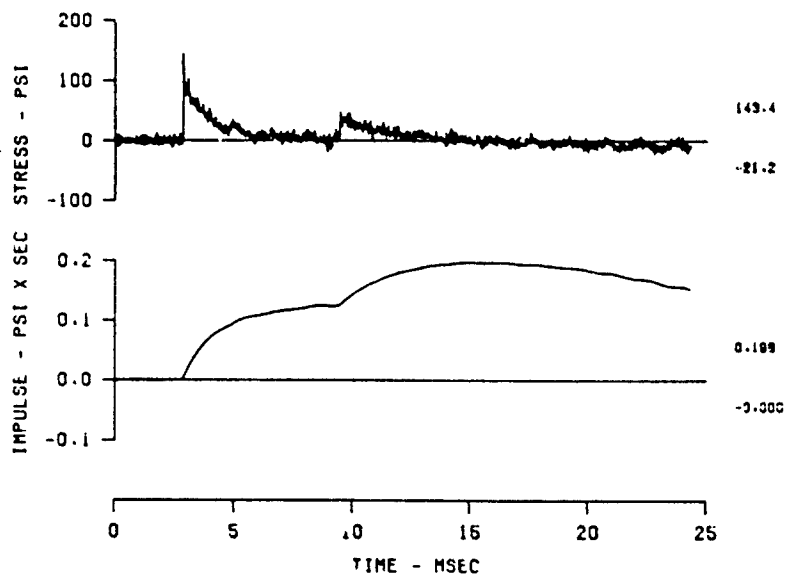
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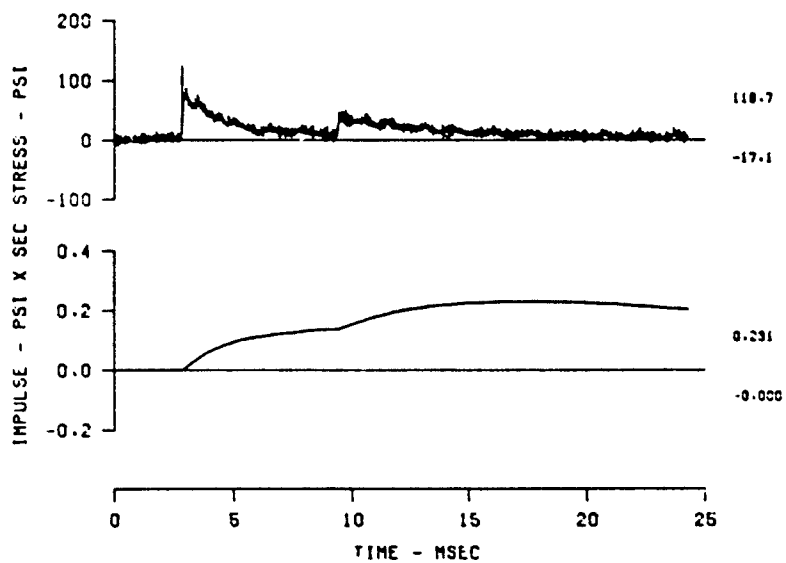
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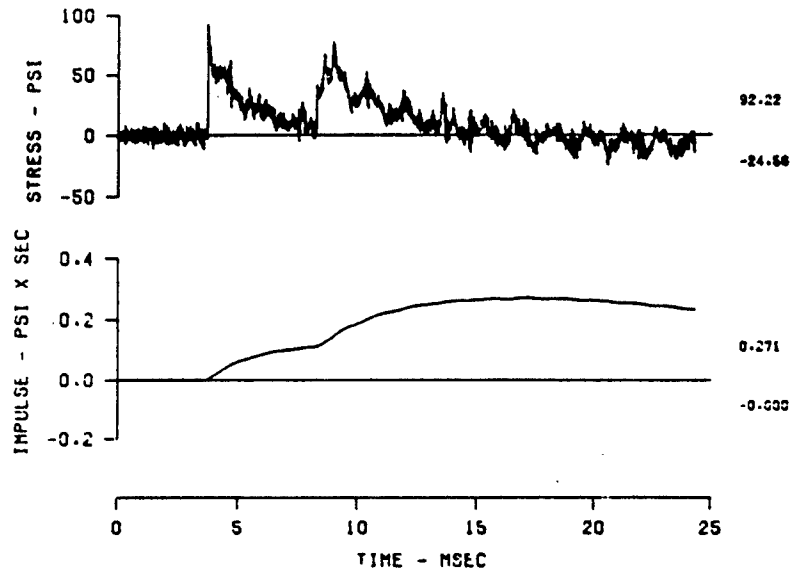
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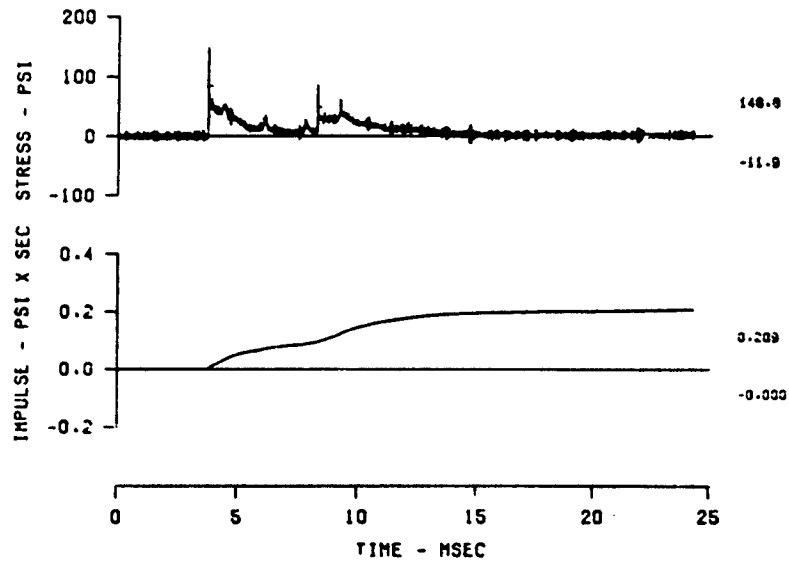
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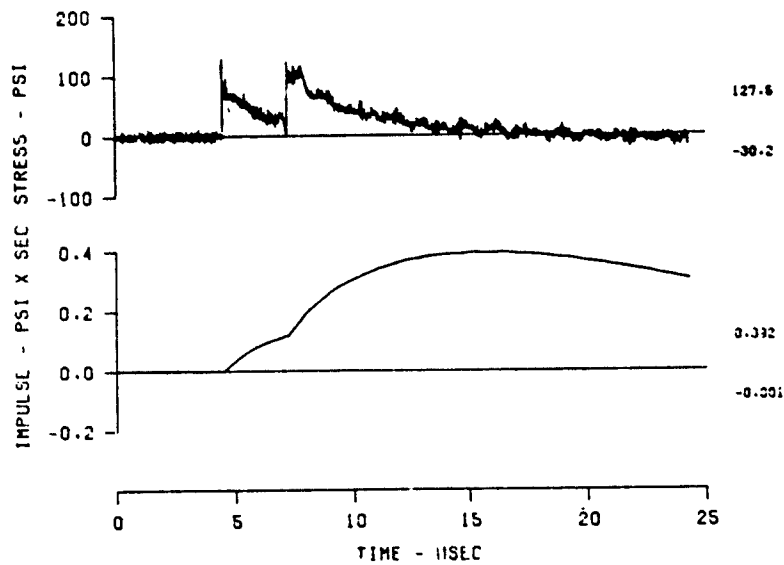
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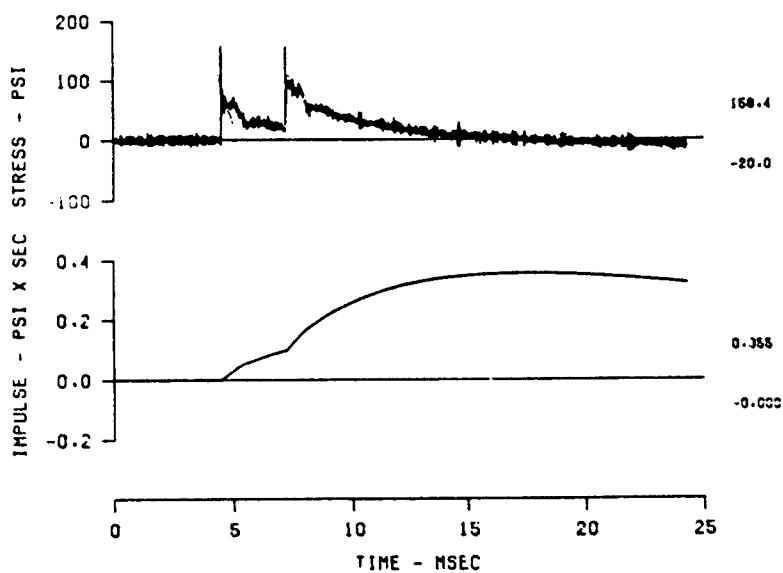
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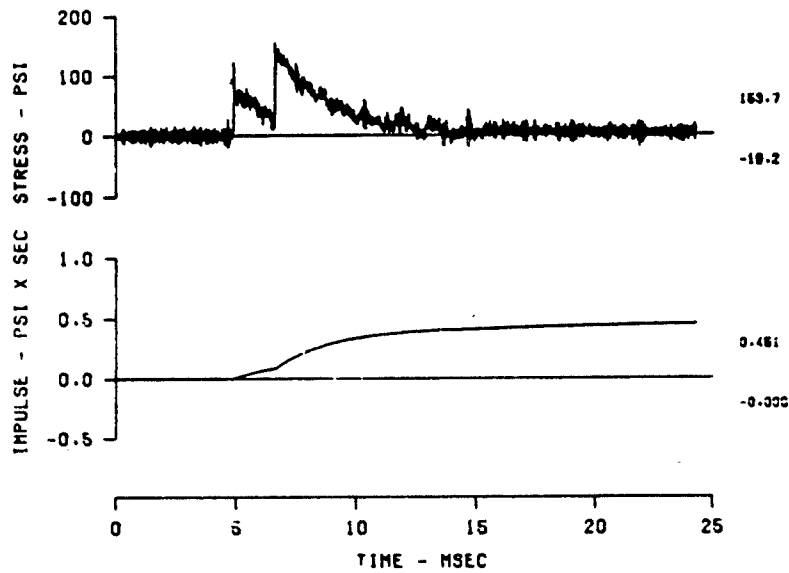
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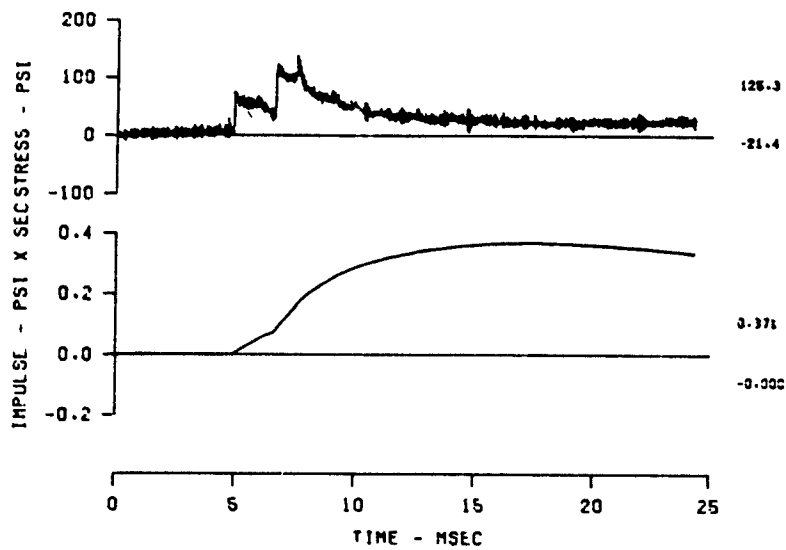
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AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/28/84

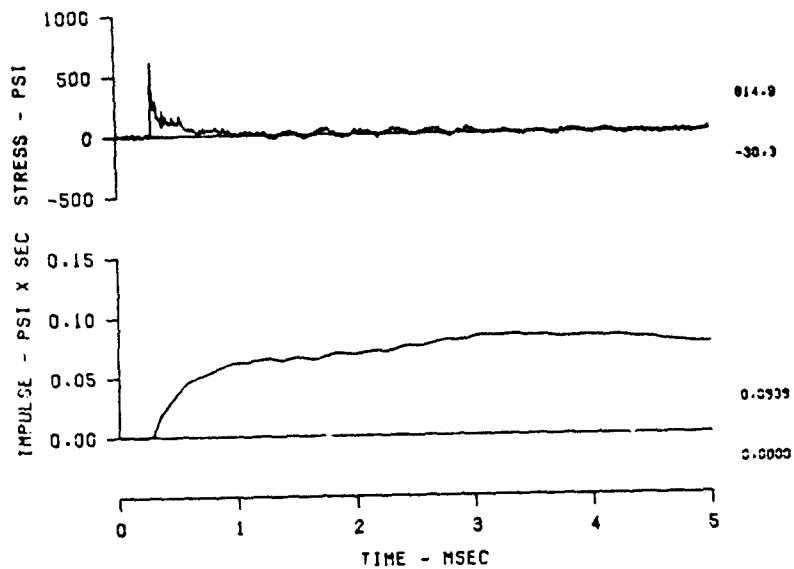


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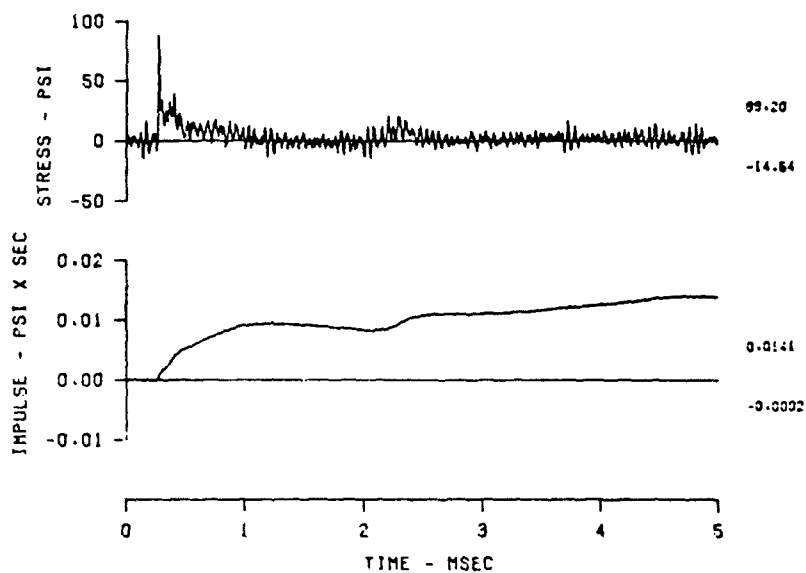


A10

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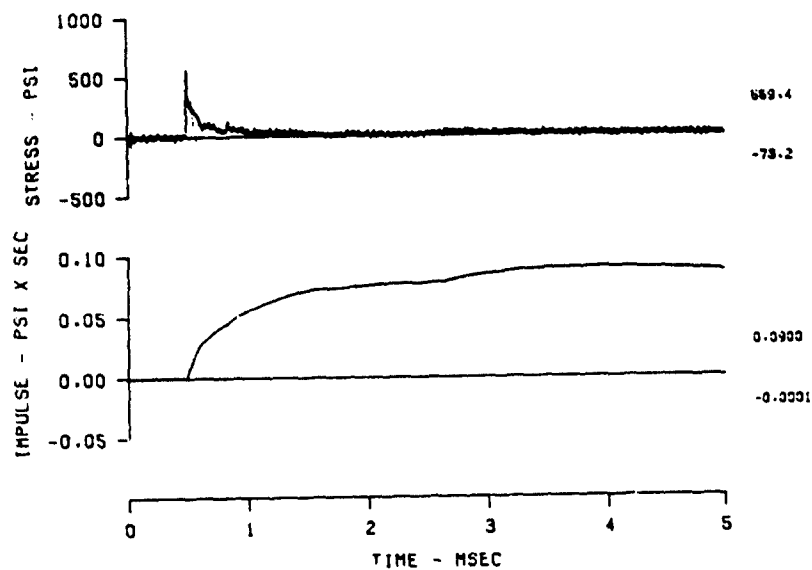


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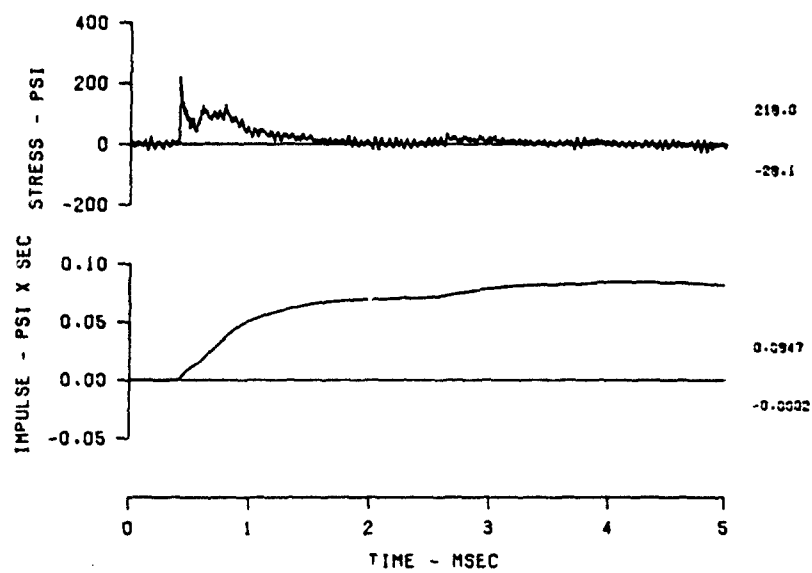


All

SHOT 2 CH 4 3
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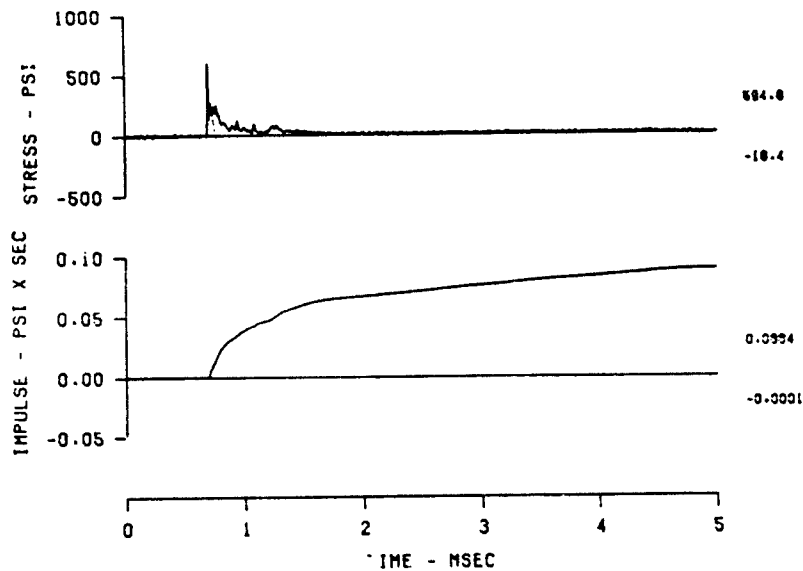


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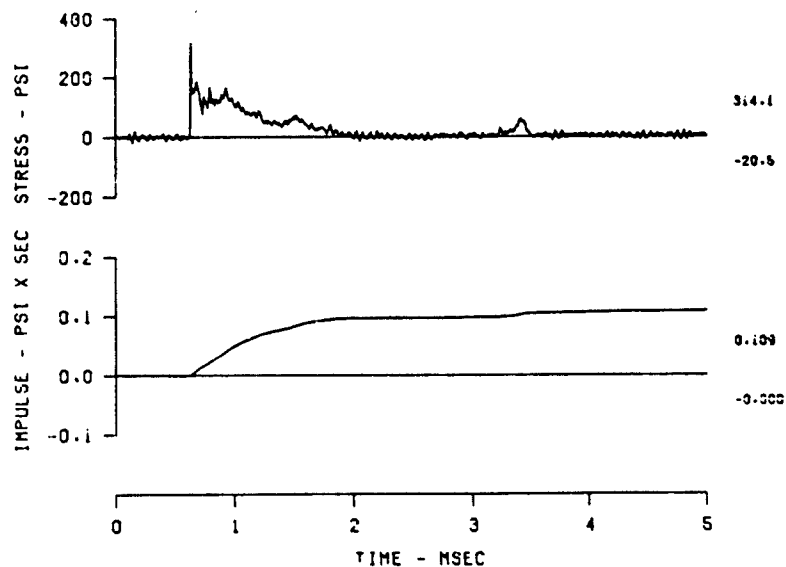


A12

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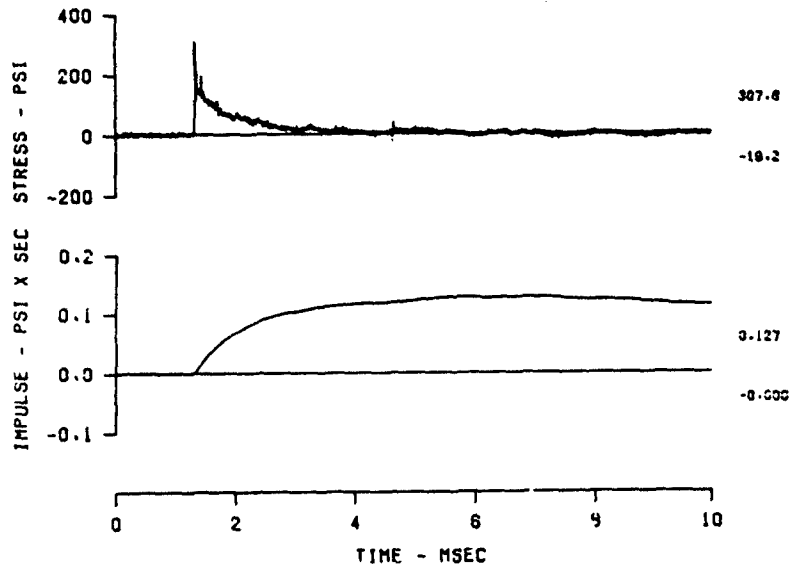


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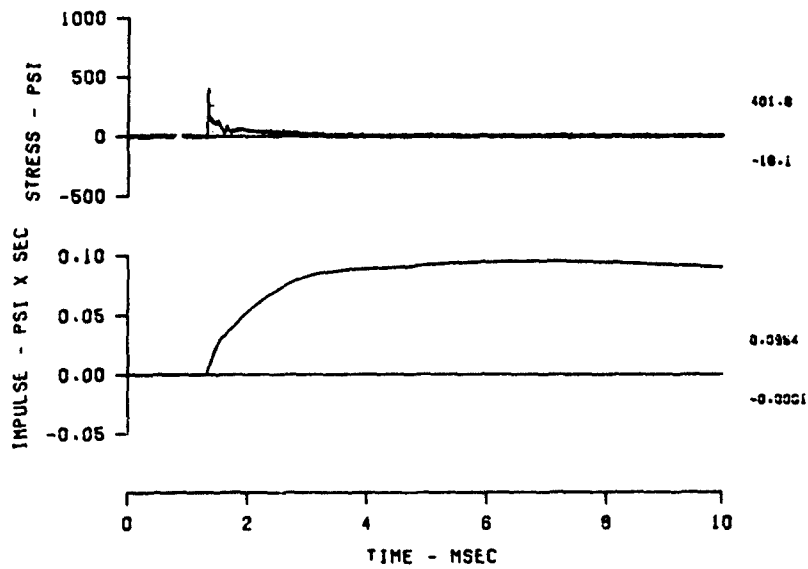


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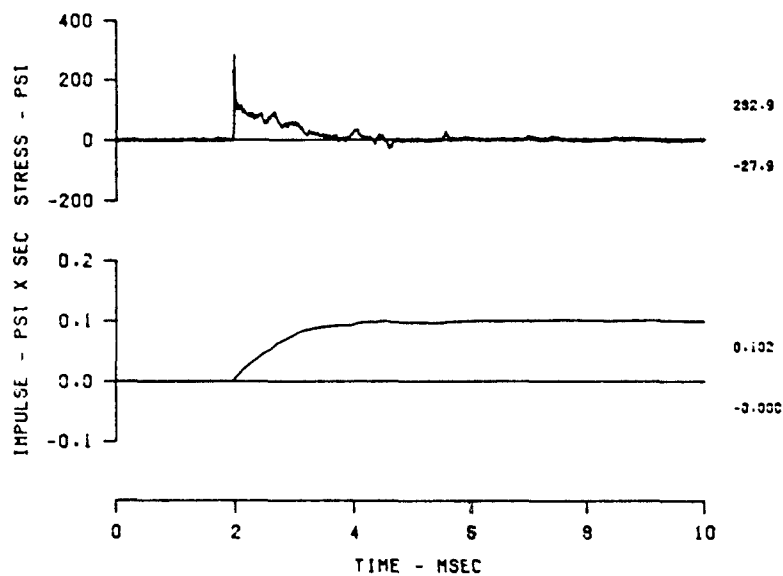
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 500000.HZ 02/28/84



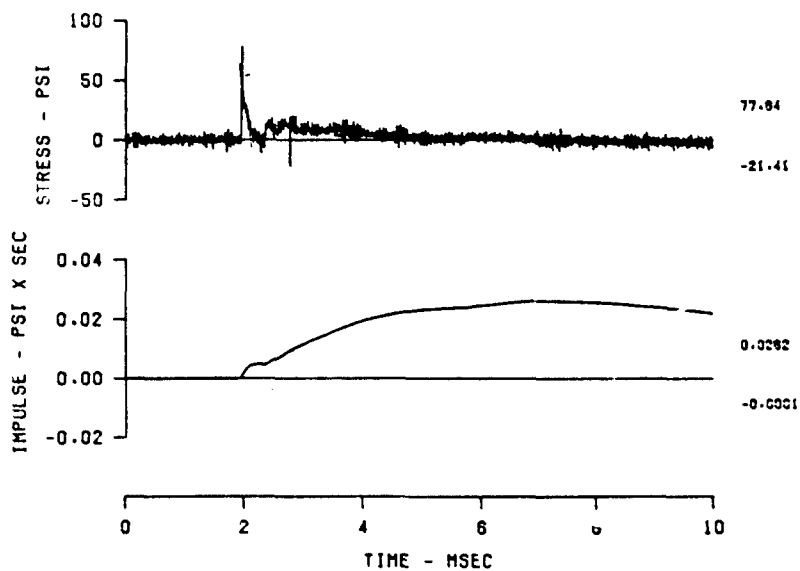
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 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/28/84



SHOT 2 CH 10 9
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/28/84

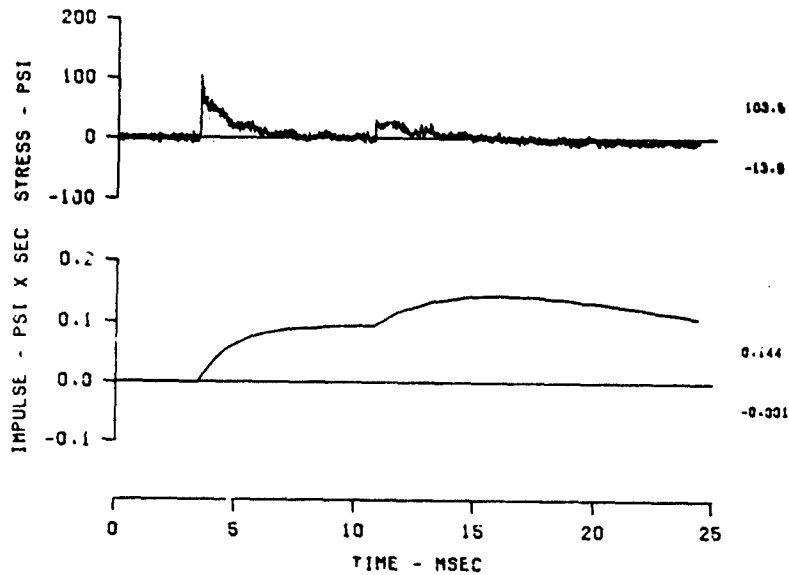


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 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/28/84

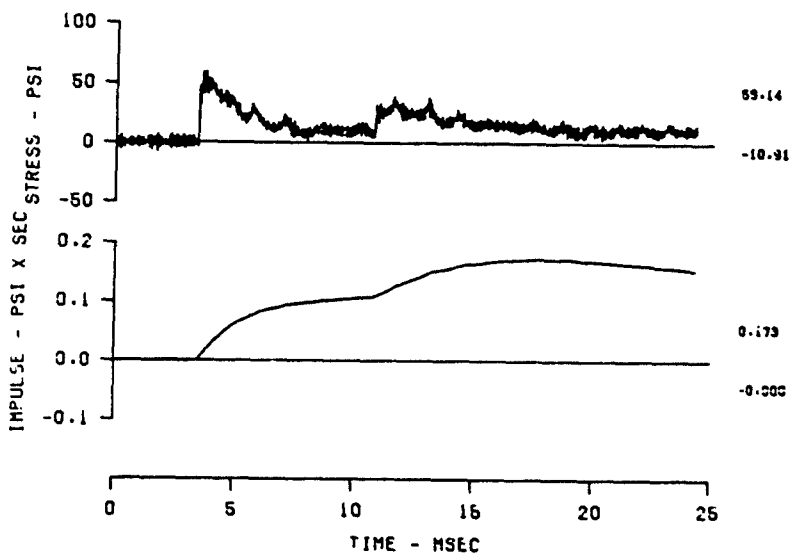


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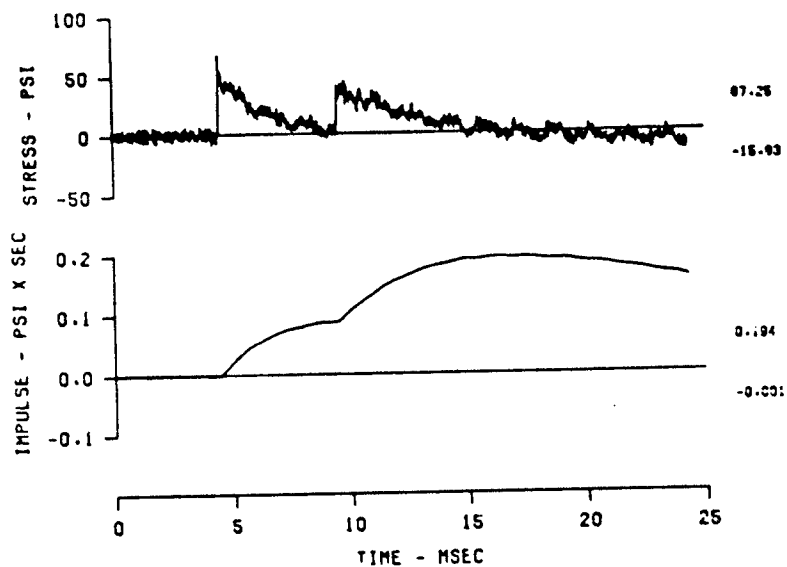
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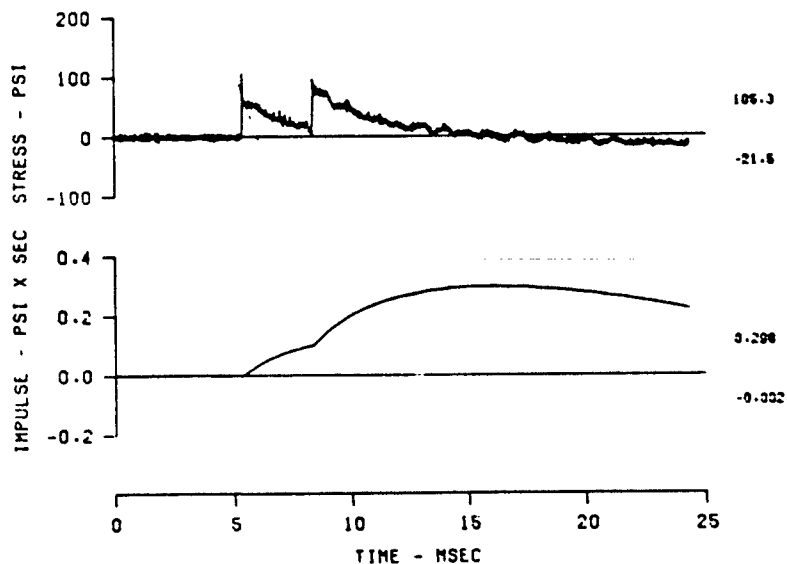
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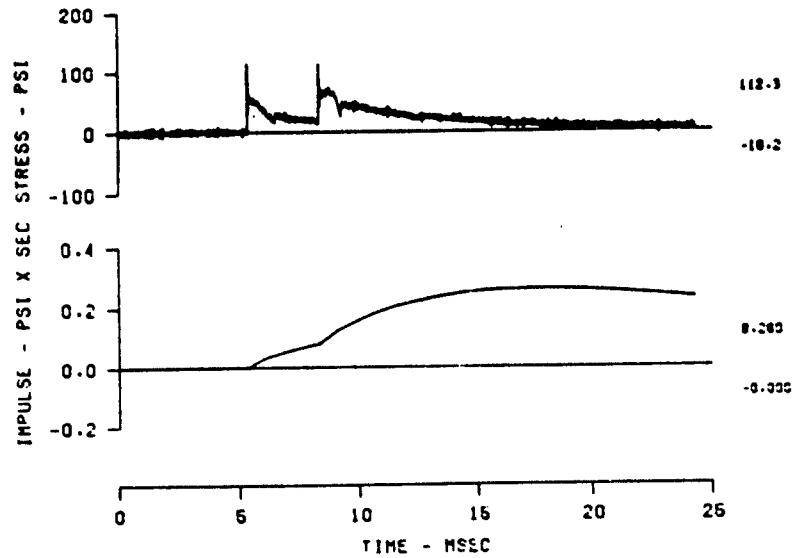
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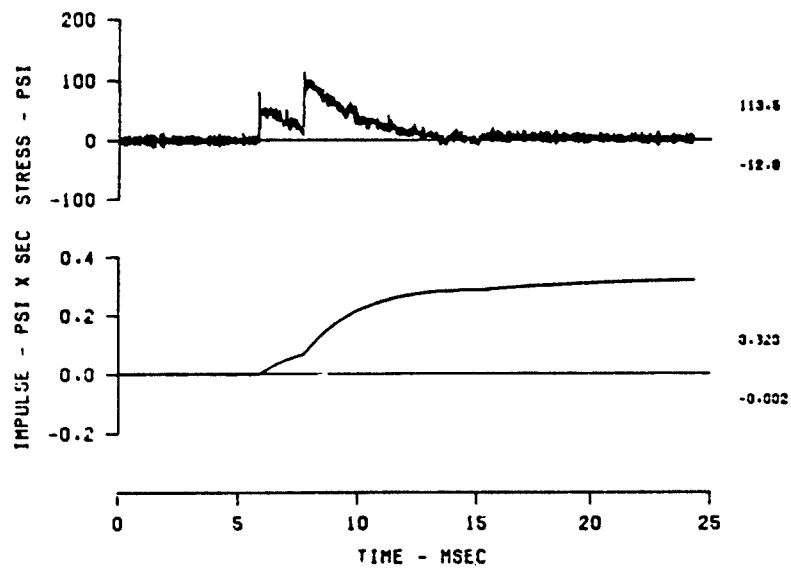
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 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/28/84



SHOT 2 CM 17 16
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/29/84

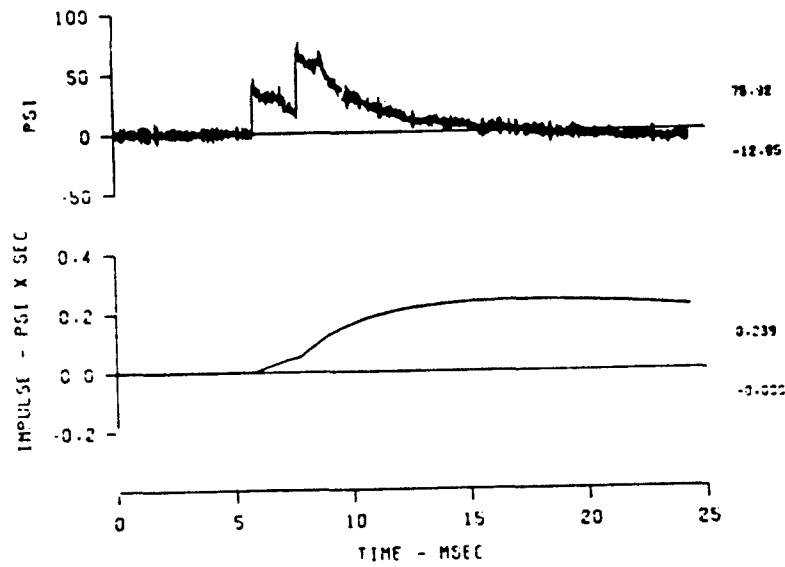


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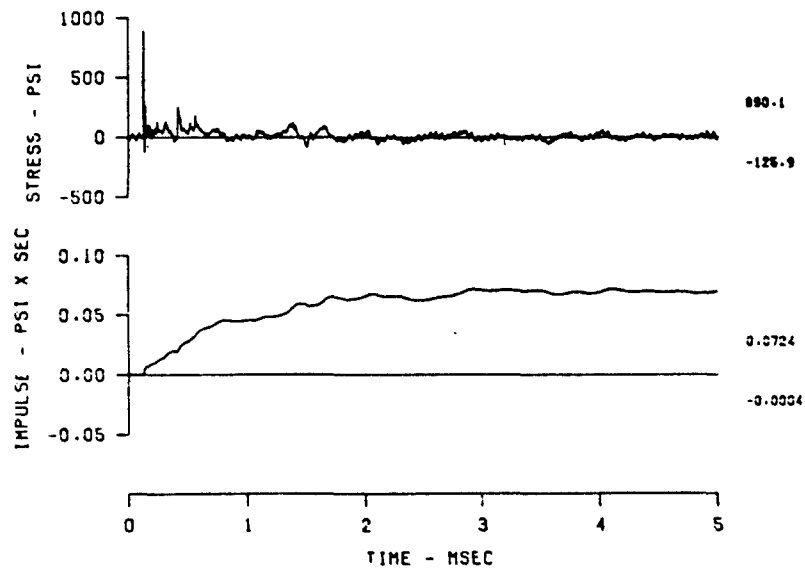


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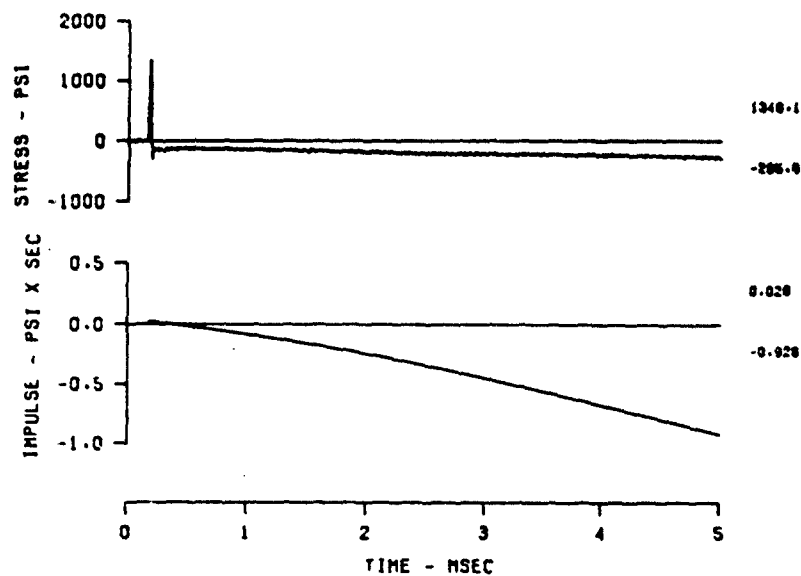
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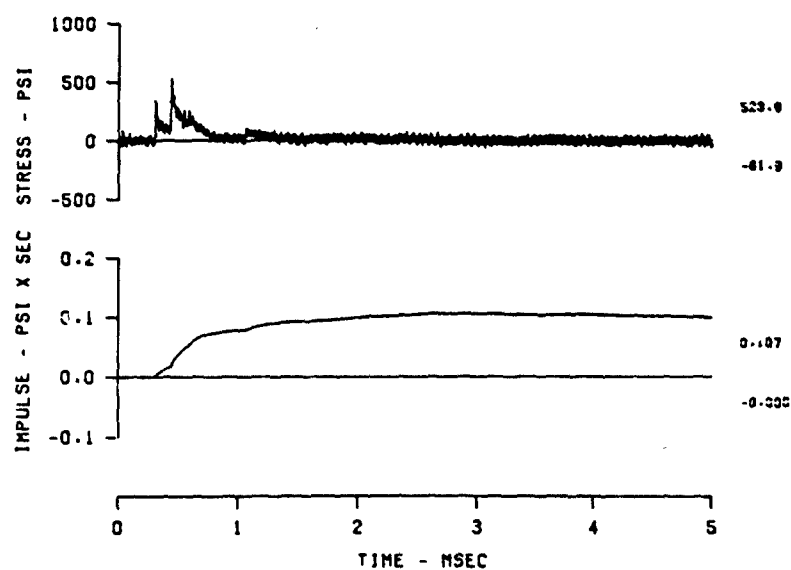
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 500000.HZ 02/28/84



SHOT 3 CH 3 2
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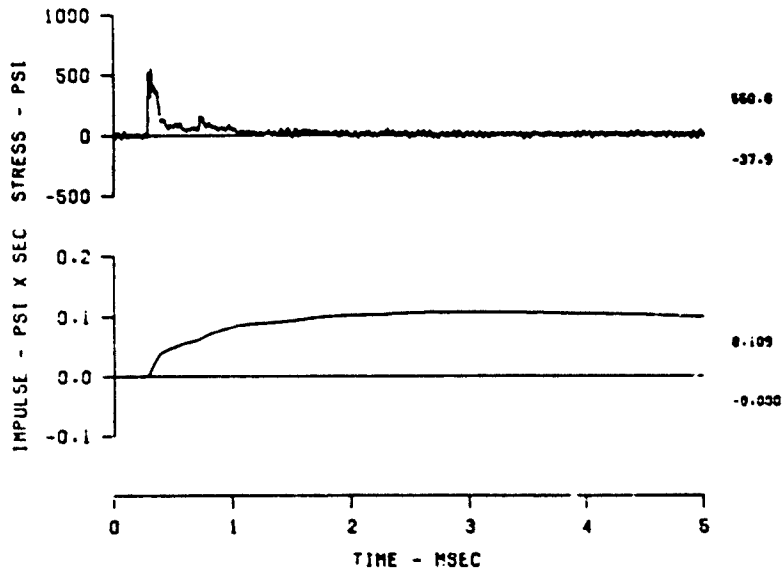


SHOT 3 CH 4 3
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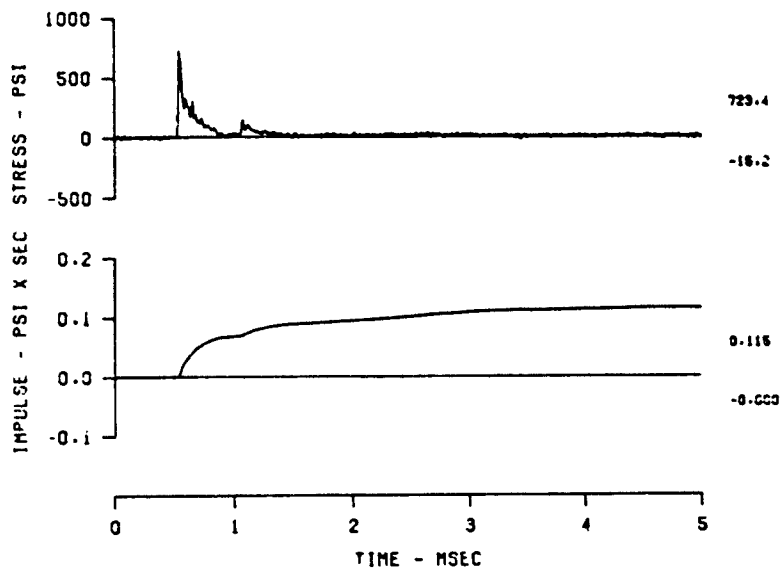


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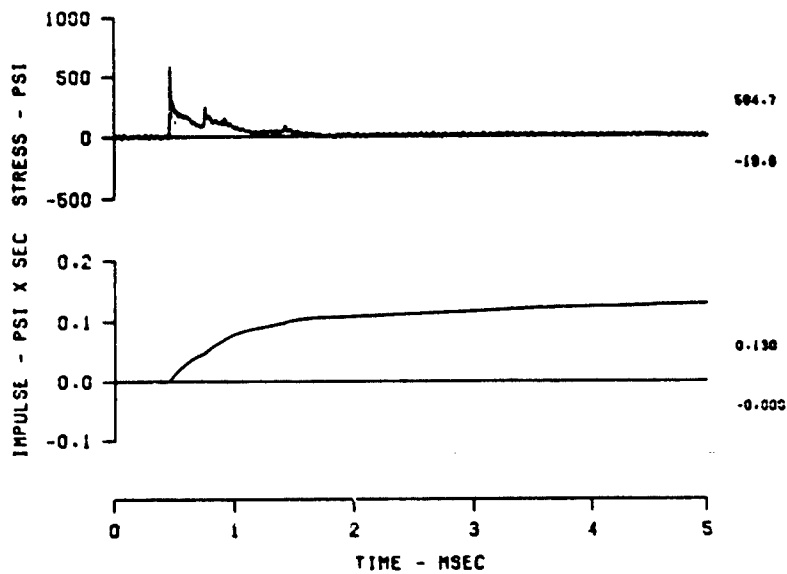
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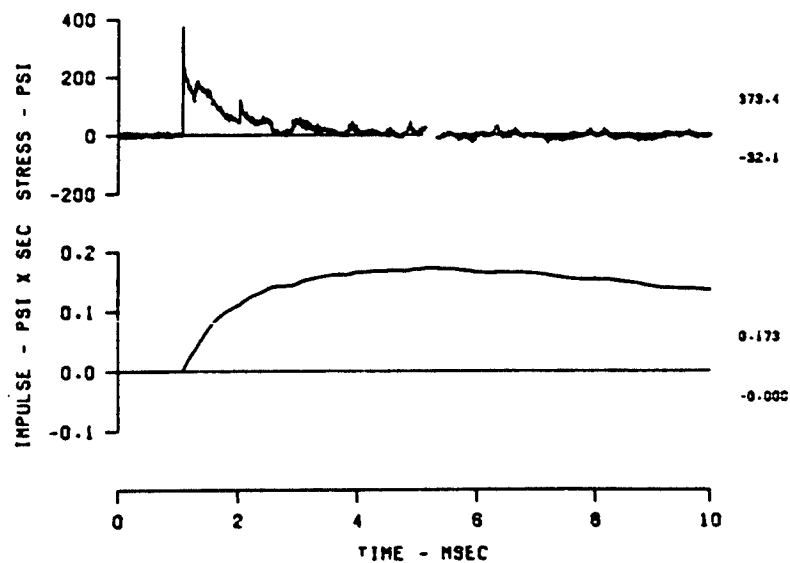
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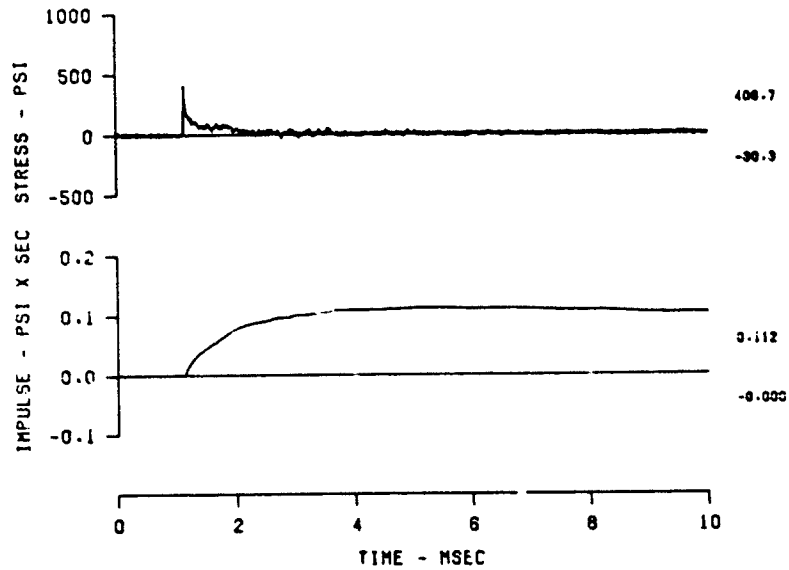
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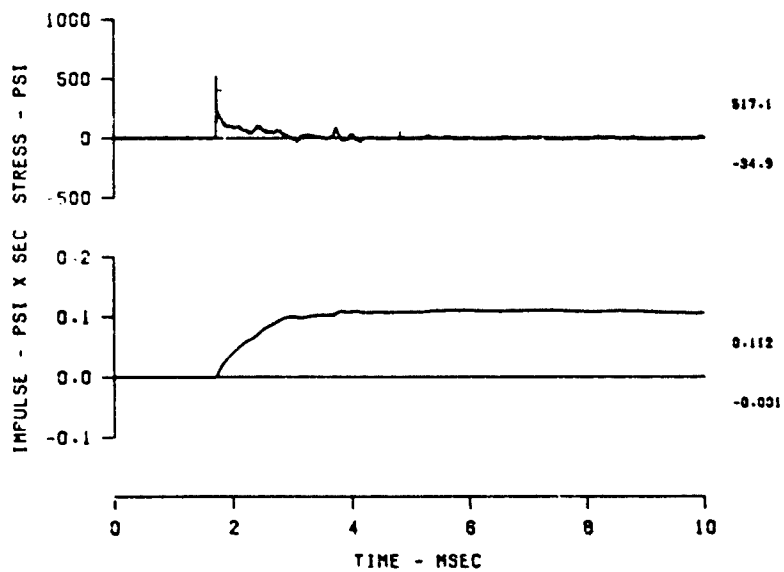
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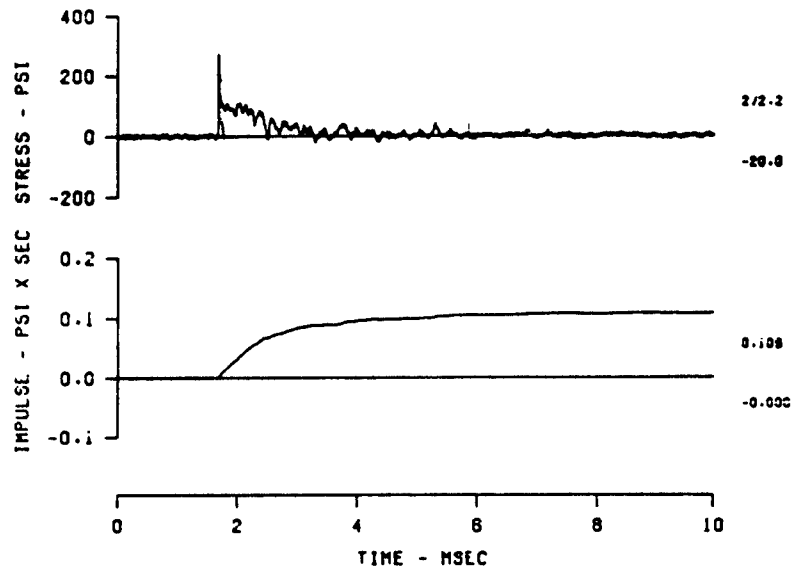
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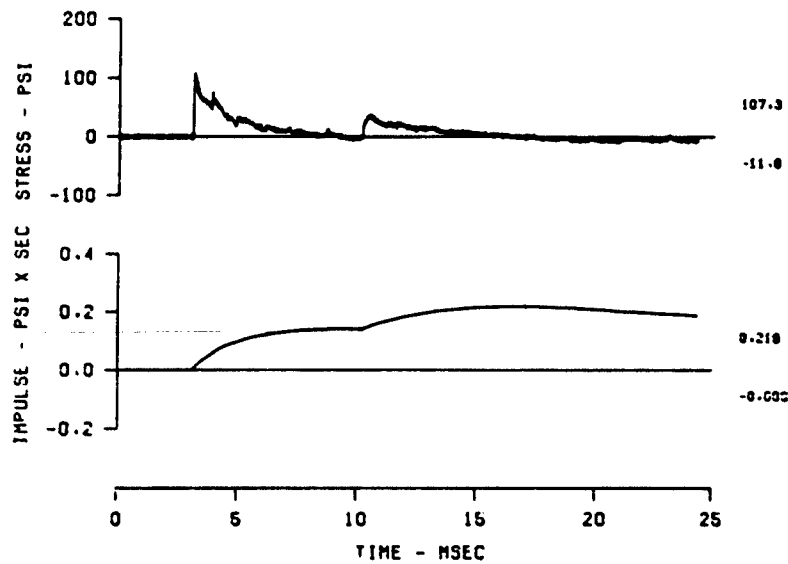
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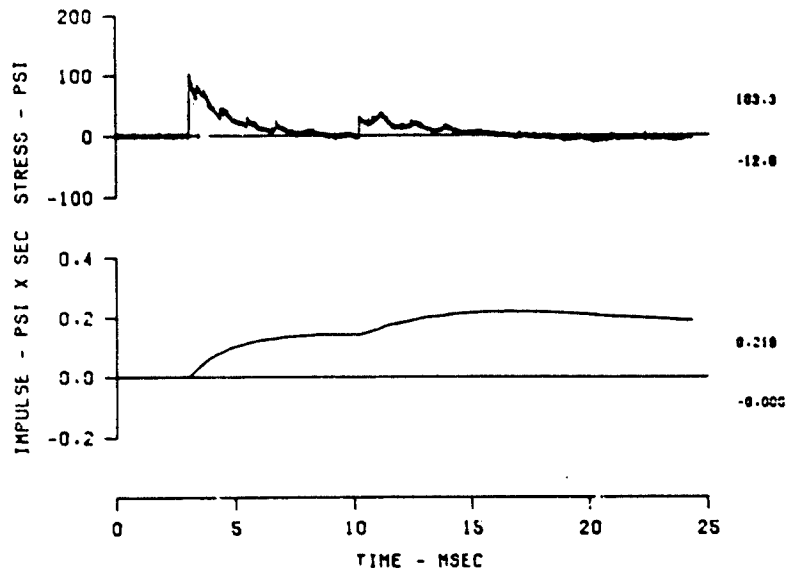
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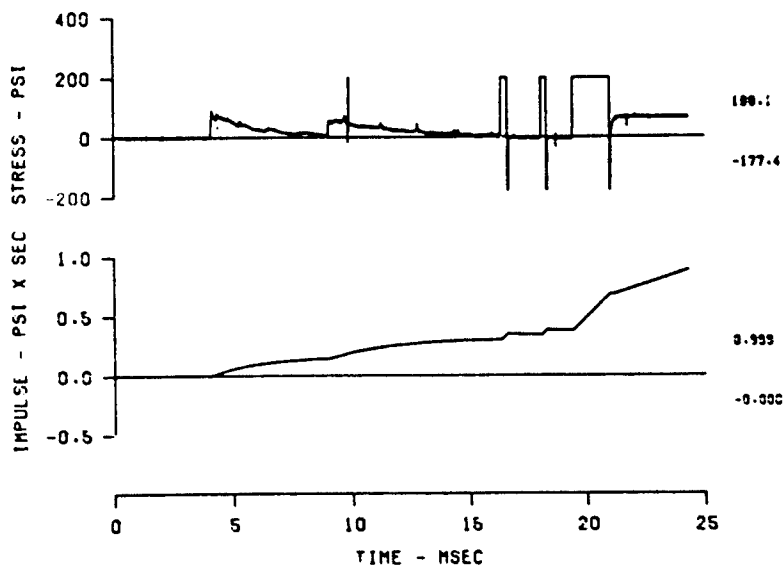
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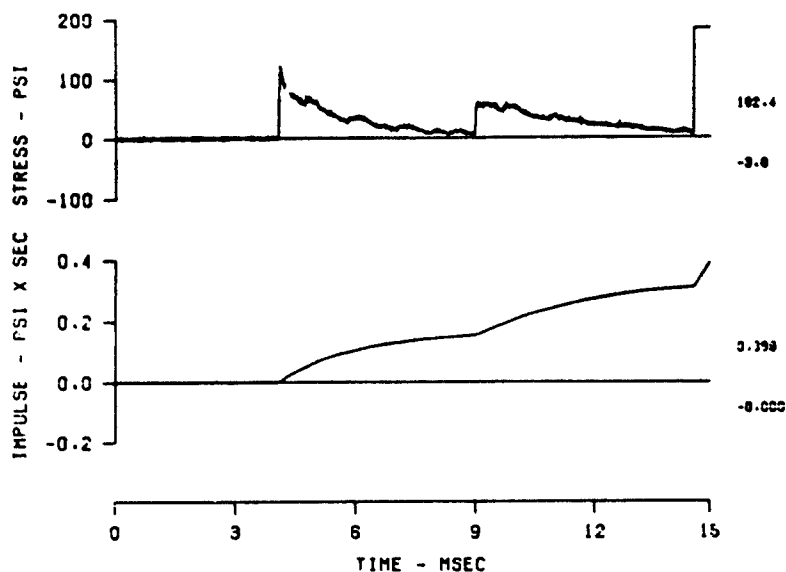
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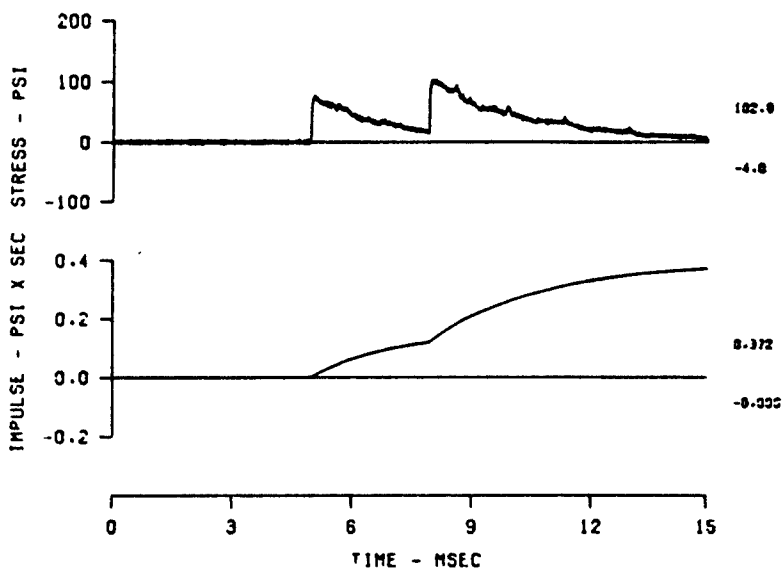
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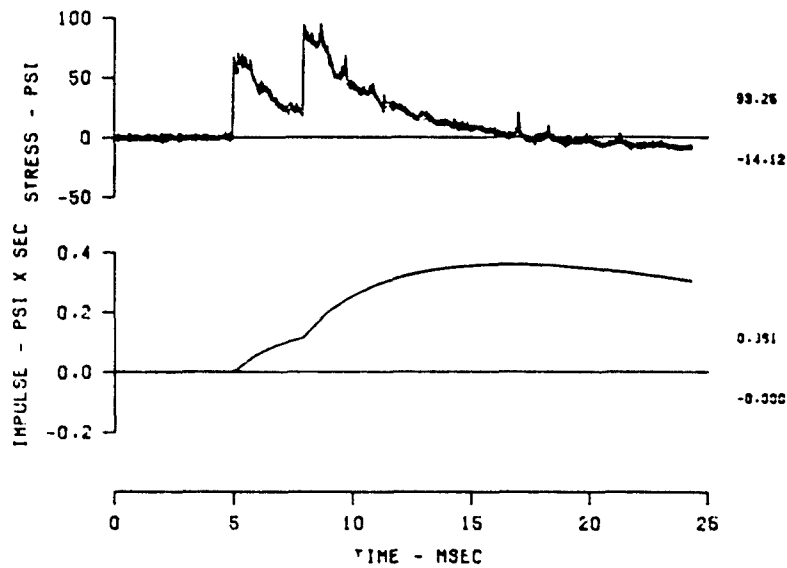
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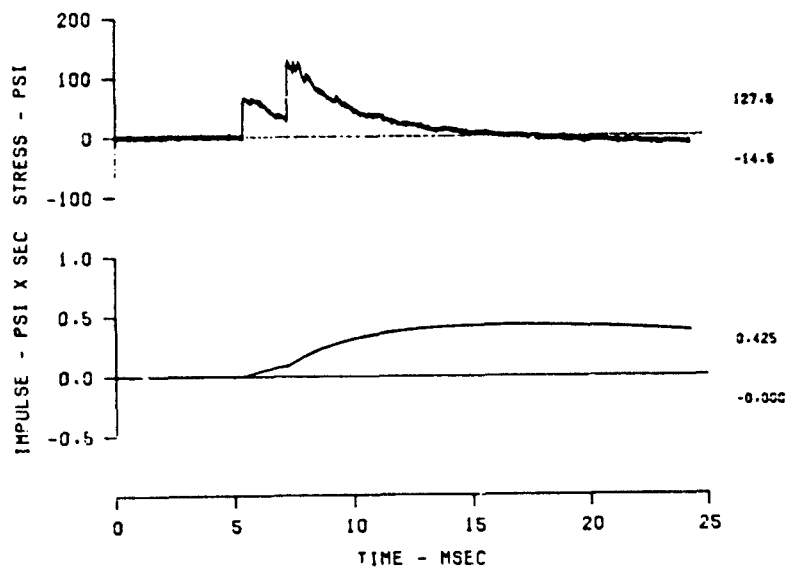
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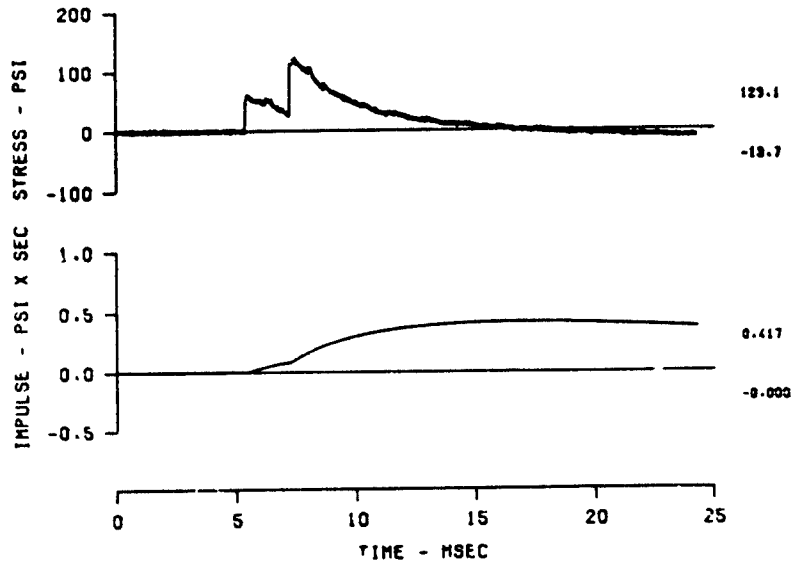
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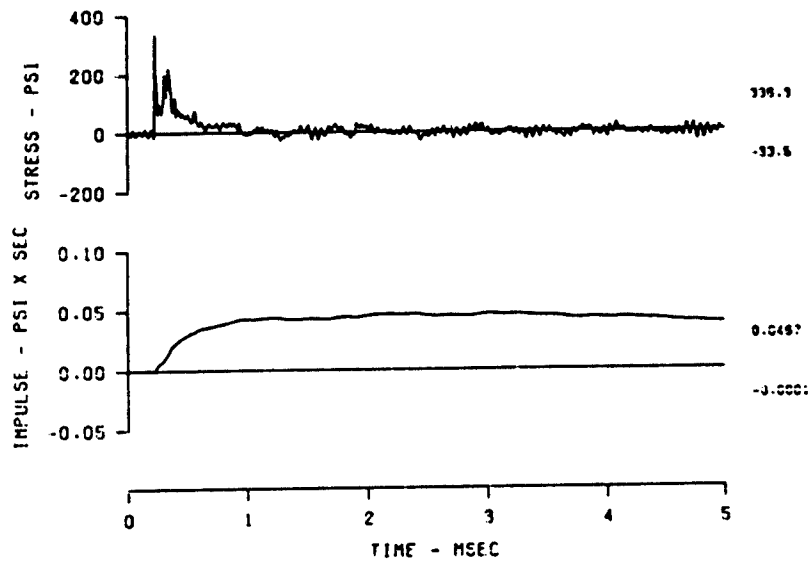
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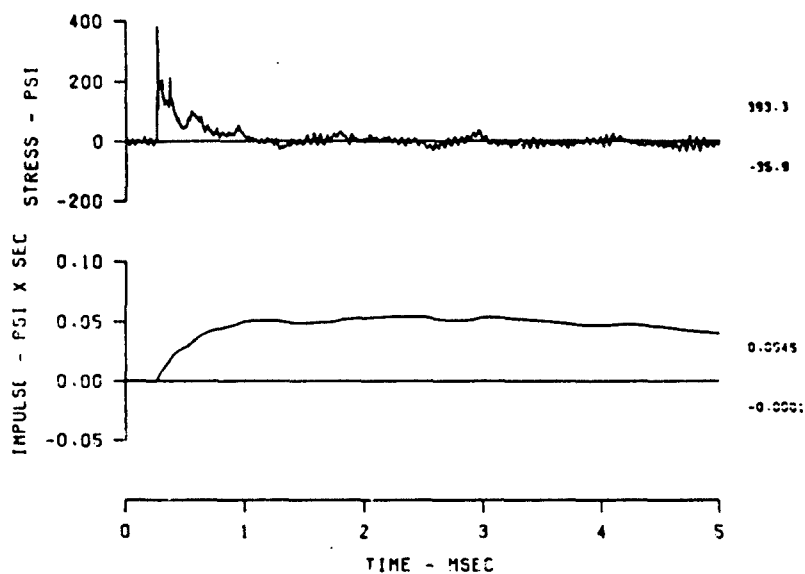
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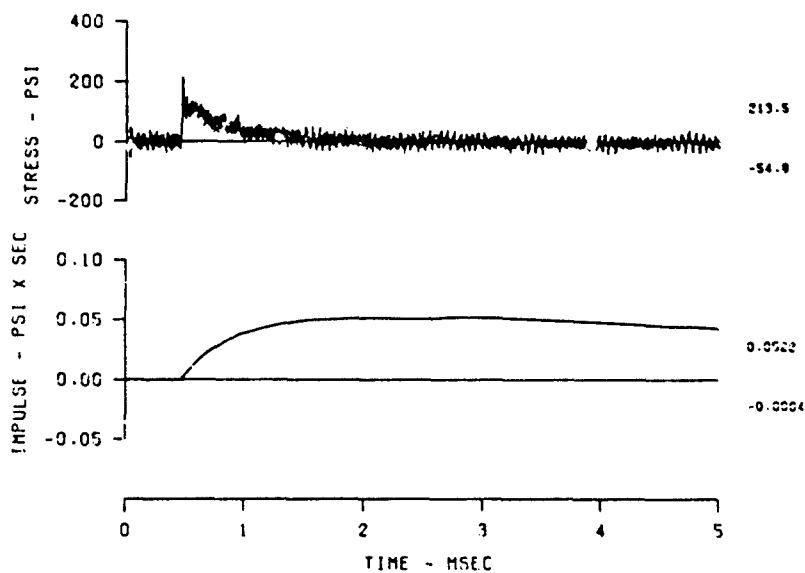
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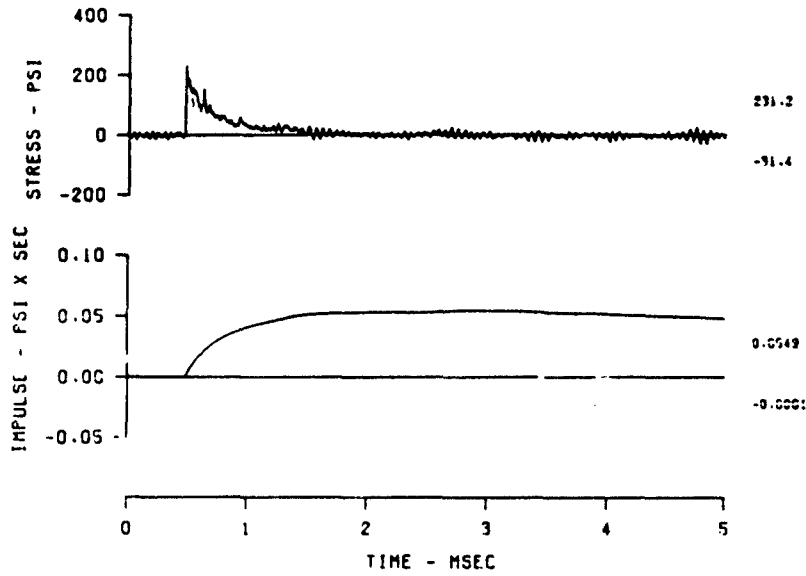
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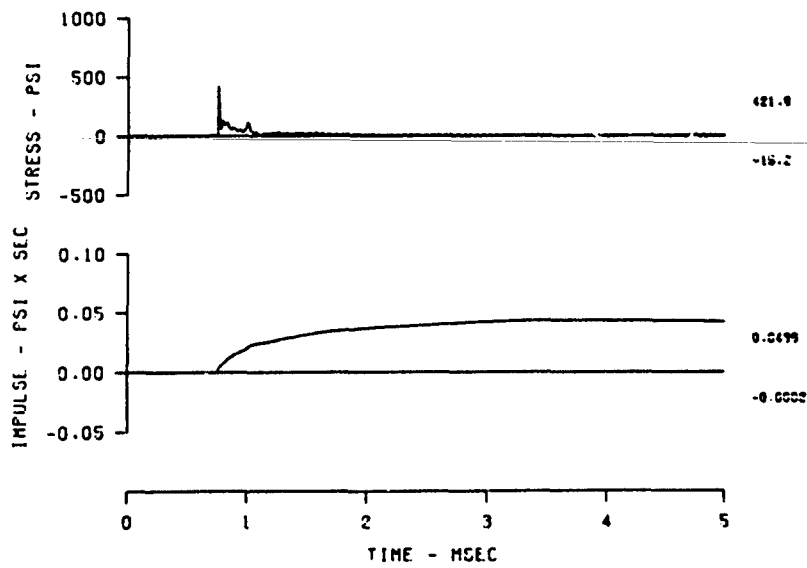
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 500000.HZ 02/27/84



SHOT 4 CH 5 4
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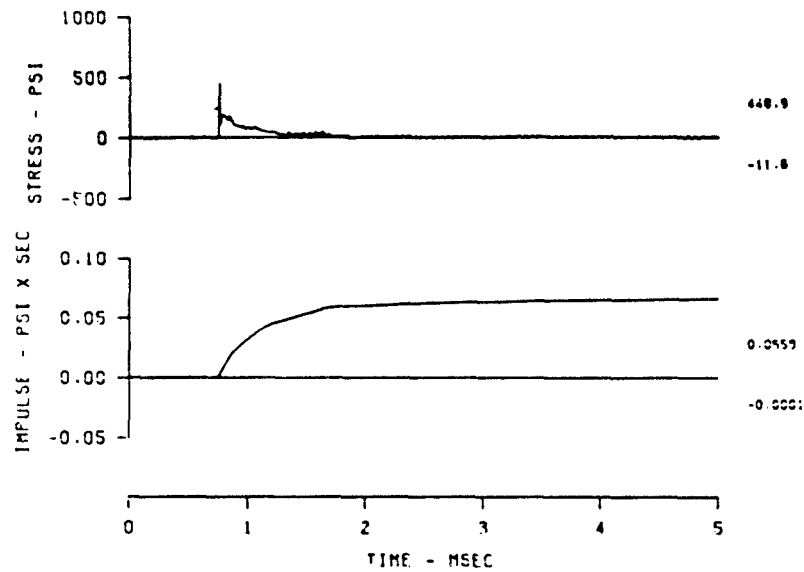


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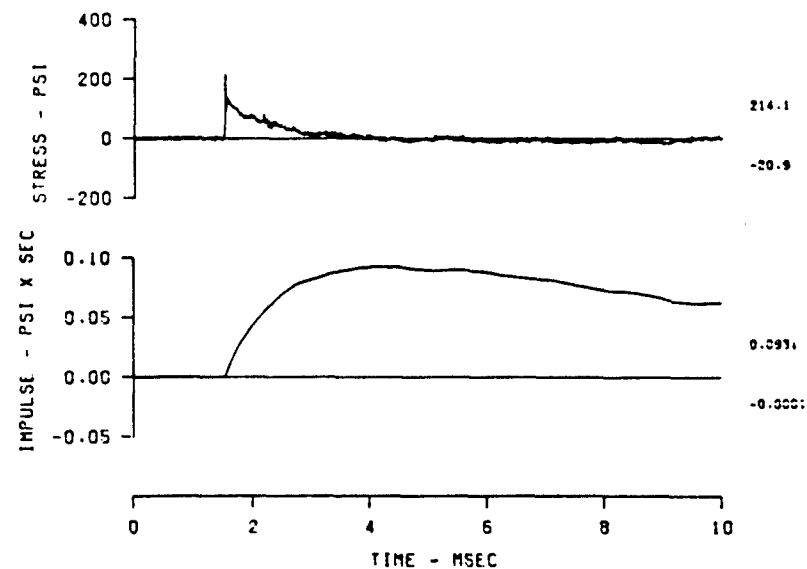


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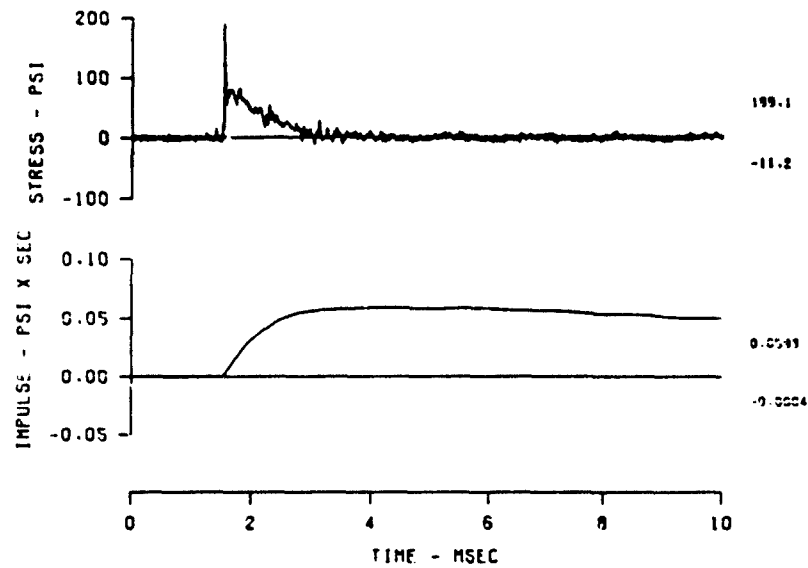
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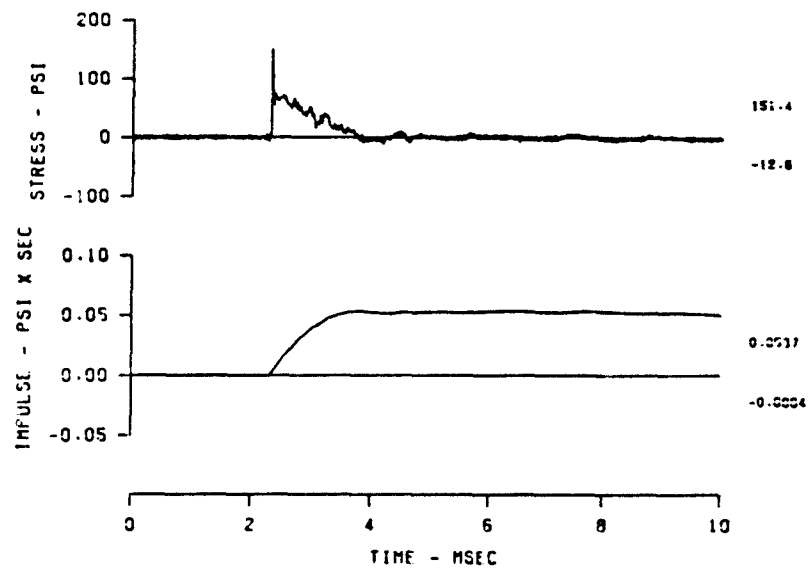
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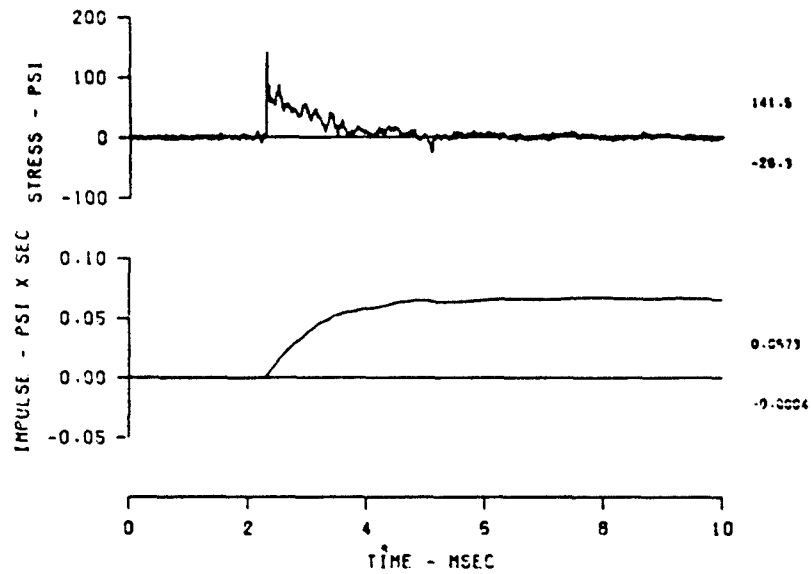
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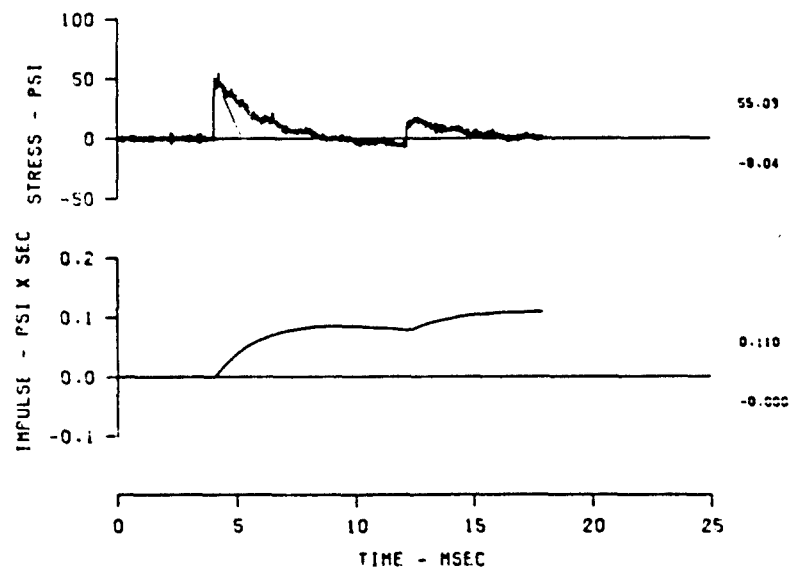
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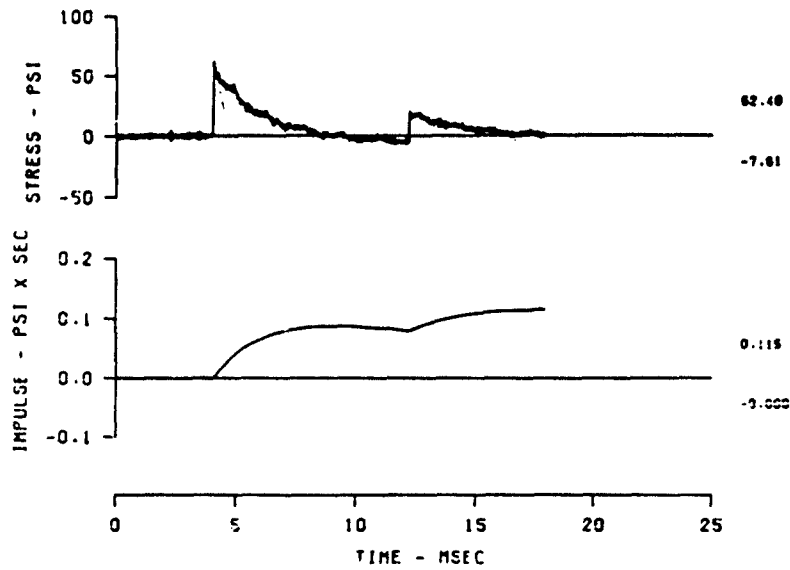
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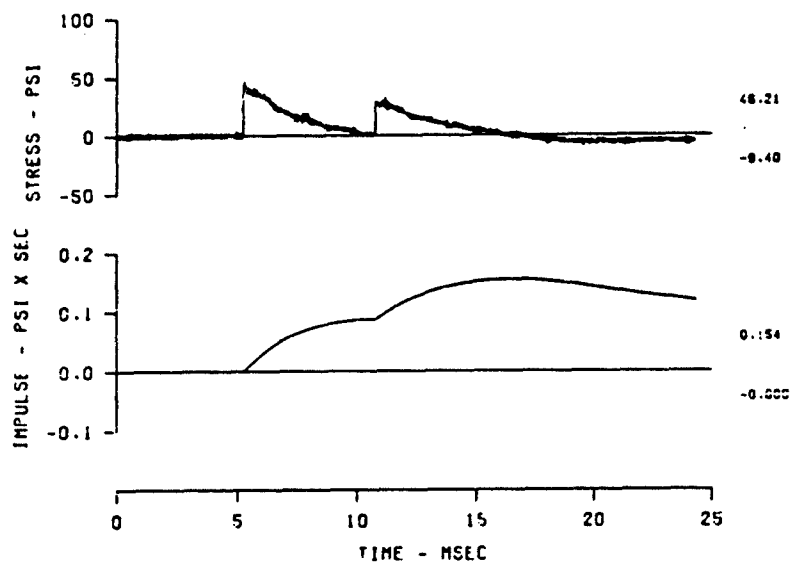
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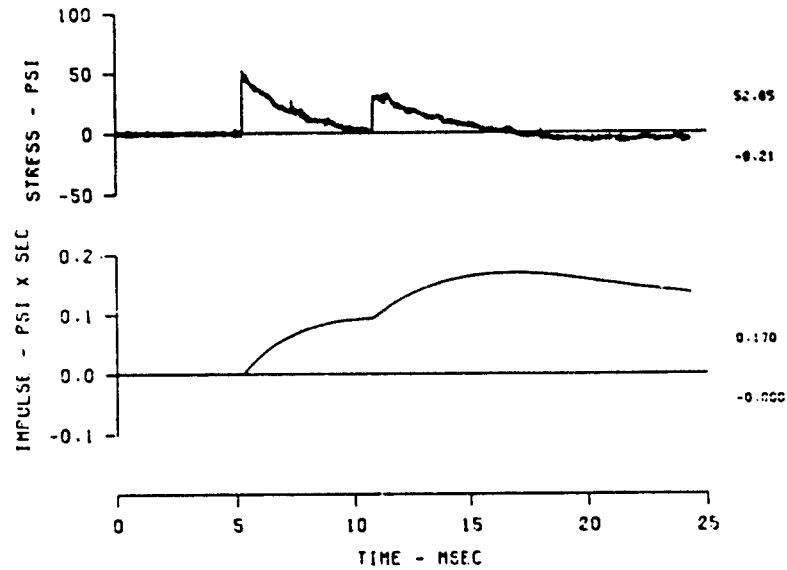
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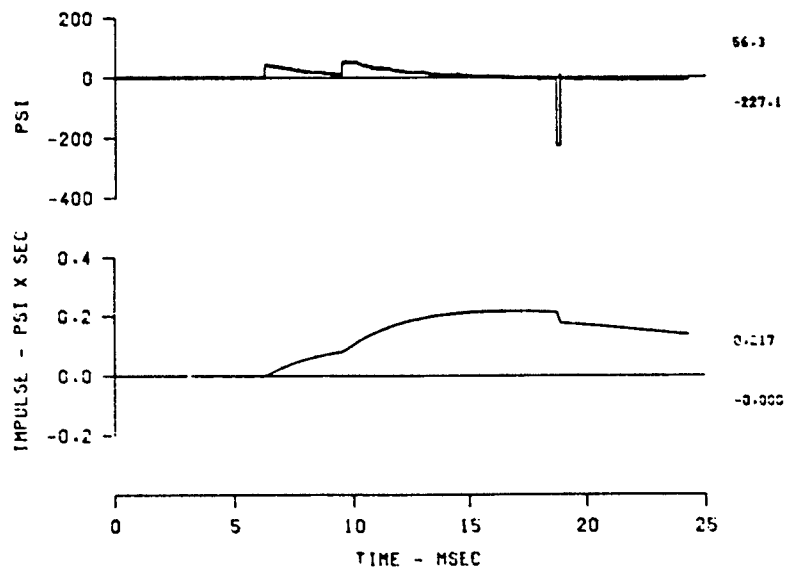
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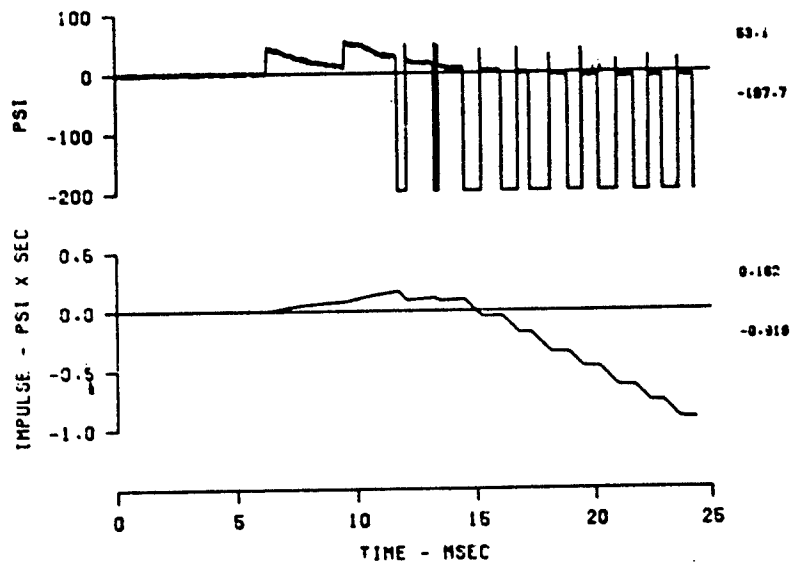
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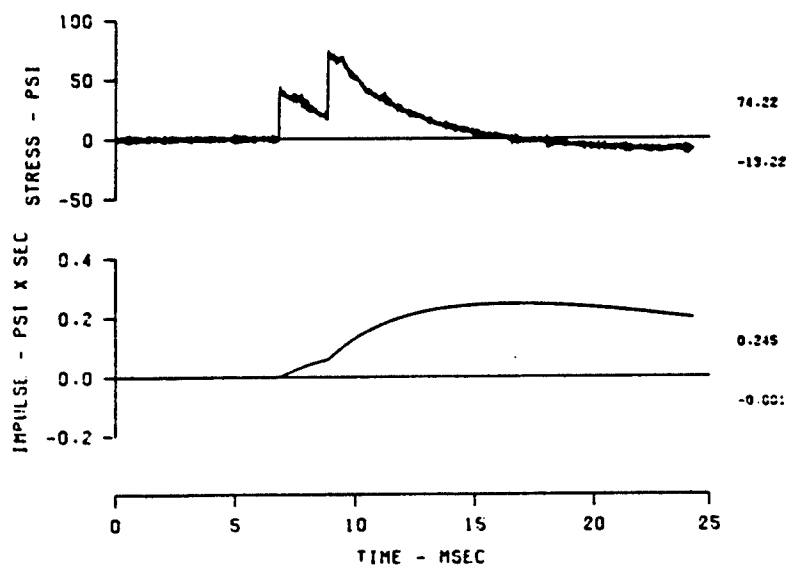
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 AIRBLAST PENETRATION 1983 LONG SQUARE TUNN
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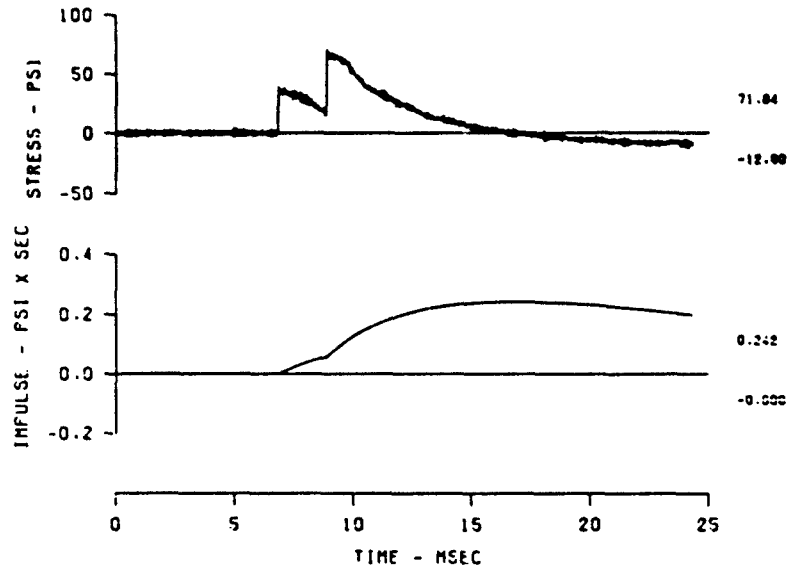
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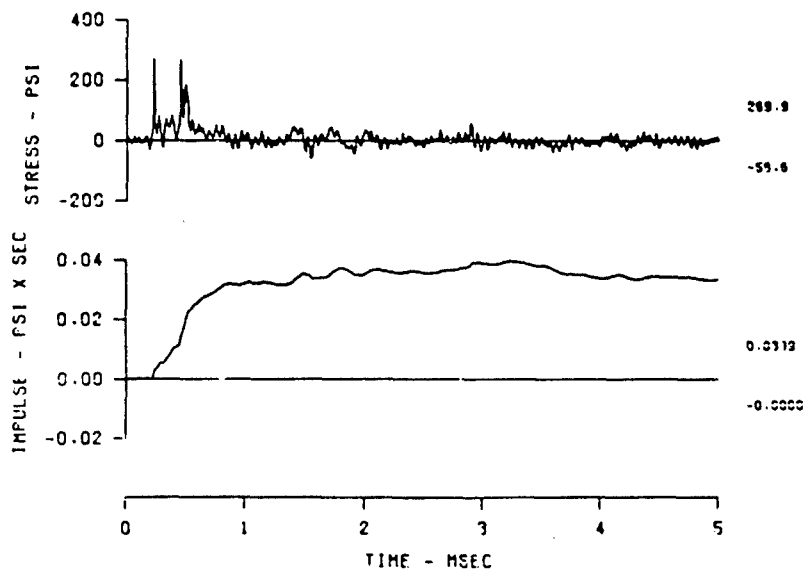
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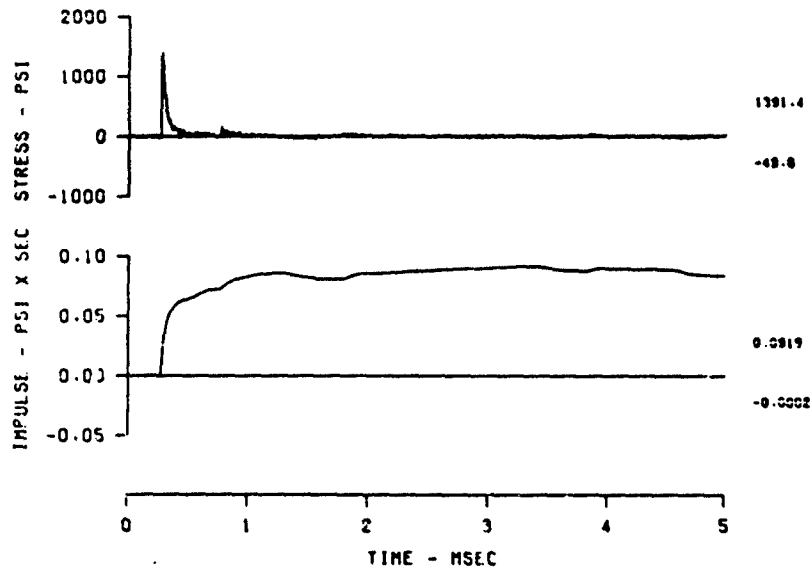
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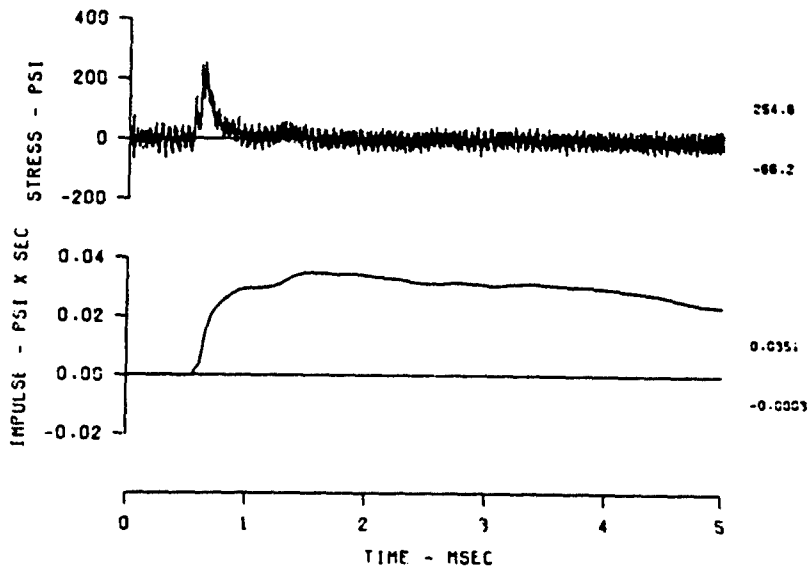
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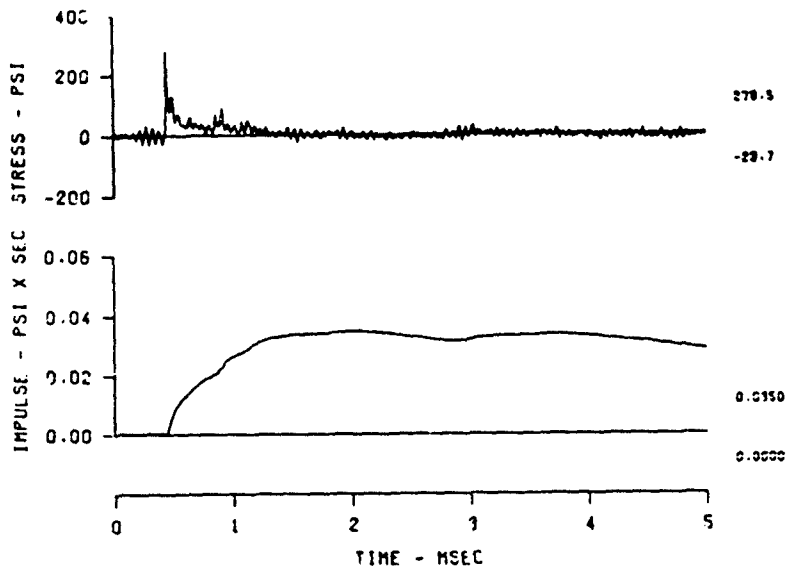
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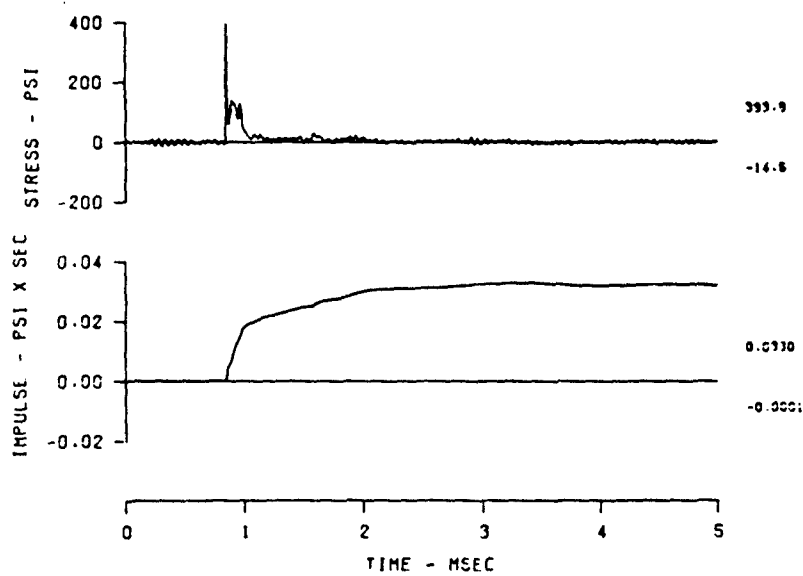
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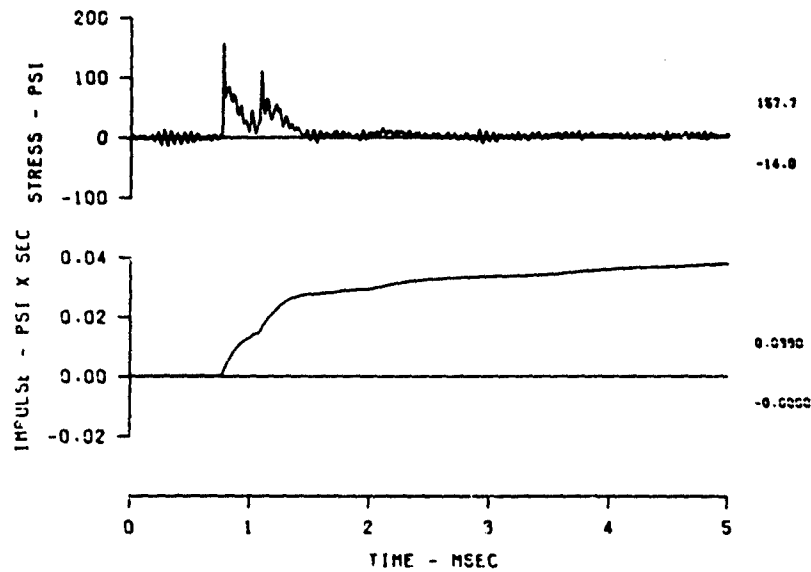
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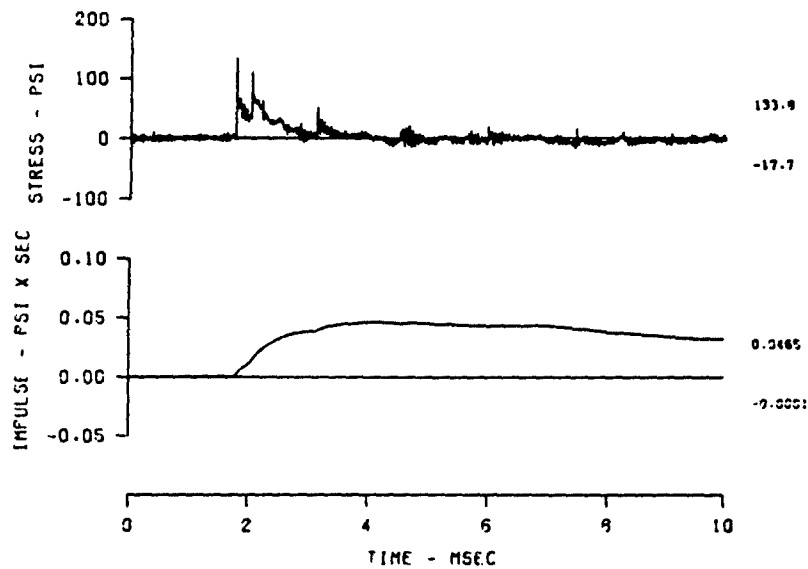
SHOT 5 CH 6 5
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84



SHOT 5 CH 7 6
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500000.HZ 02/27/84

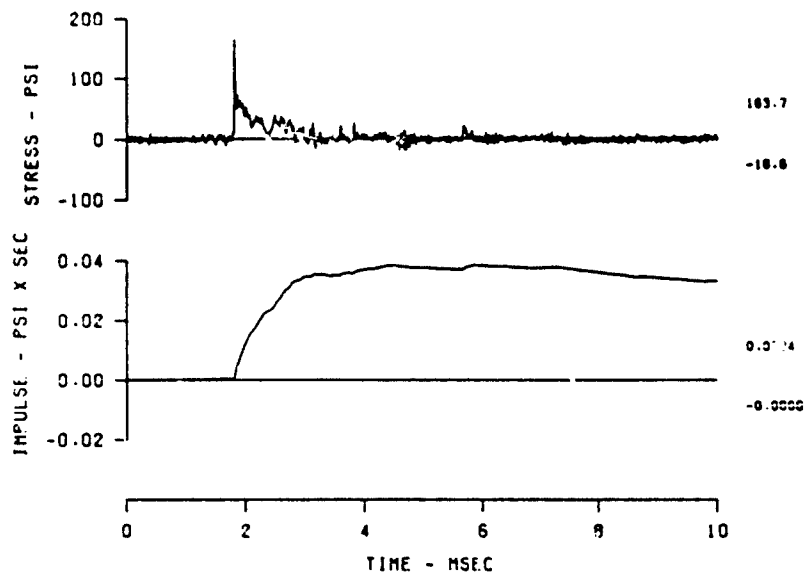


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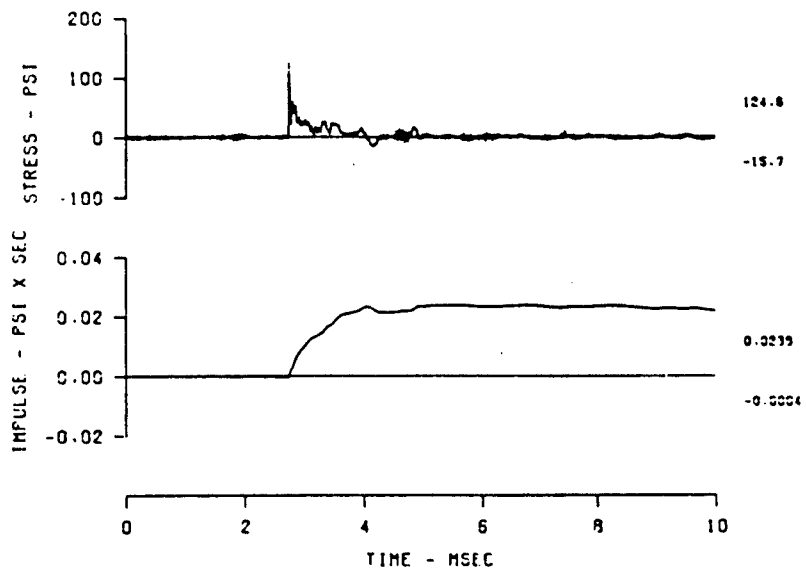


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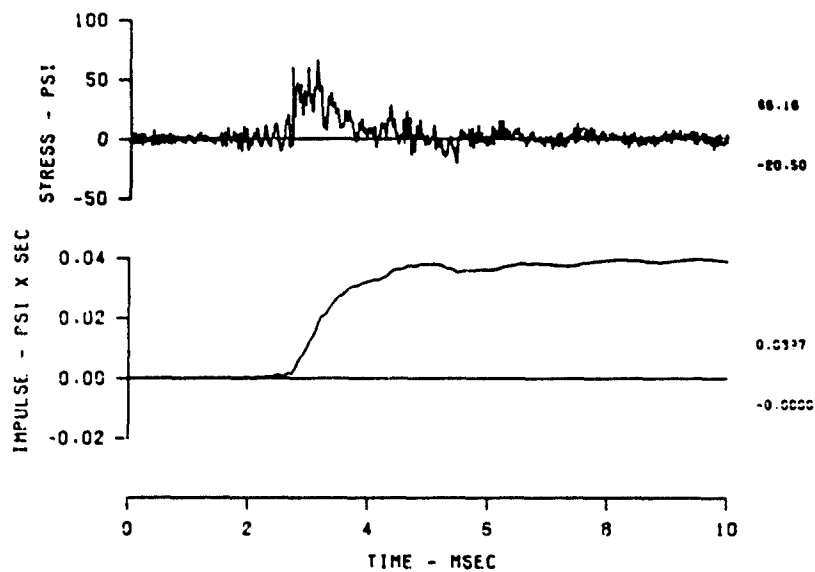
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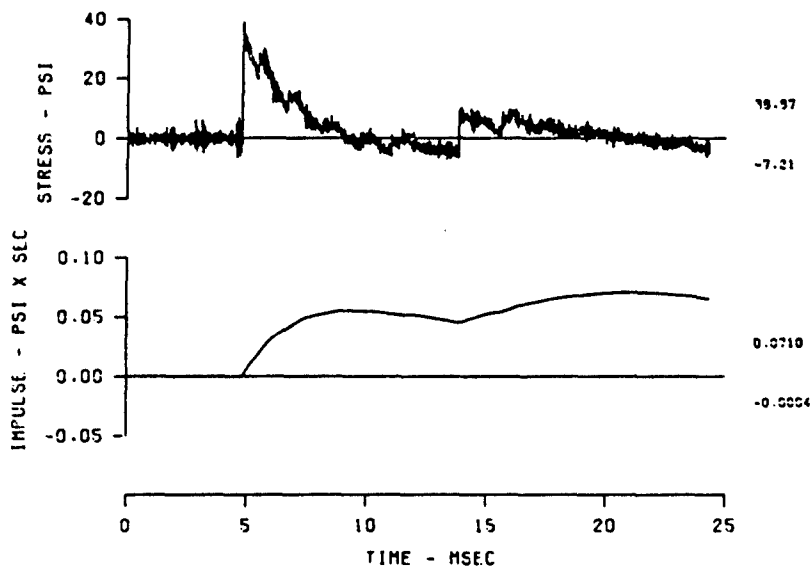
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AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84



SHOT 5 CH 11 10
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500000.HZ 02/27/84

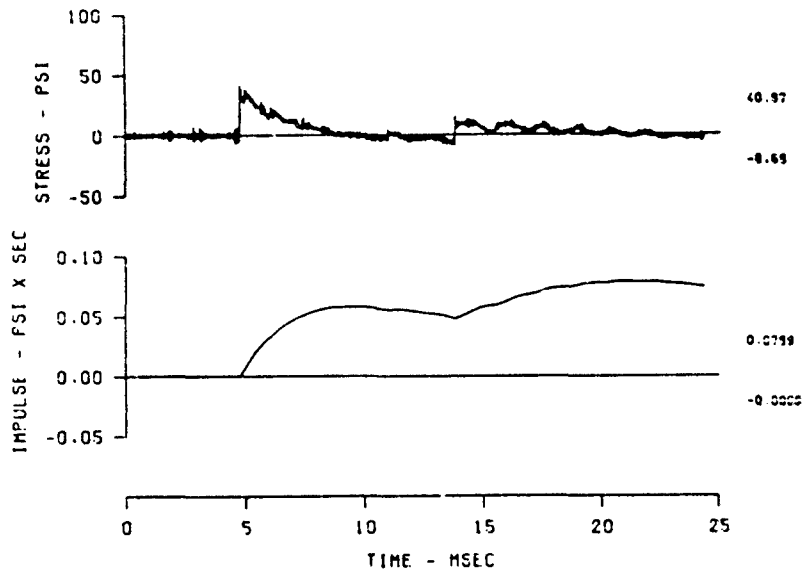


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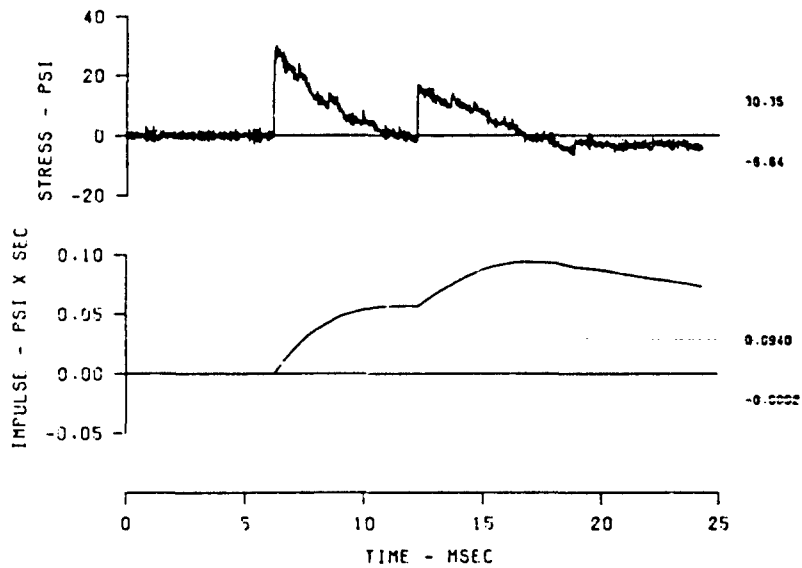


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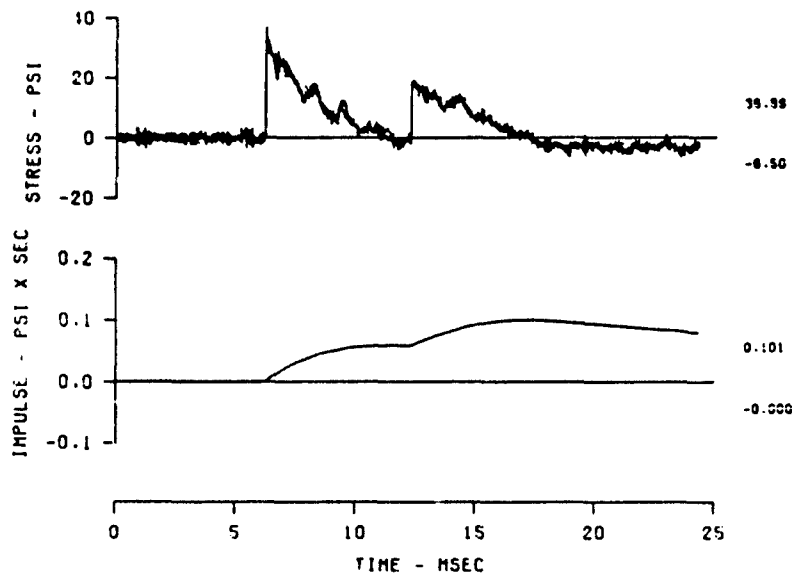


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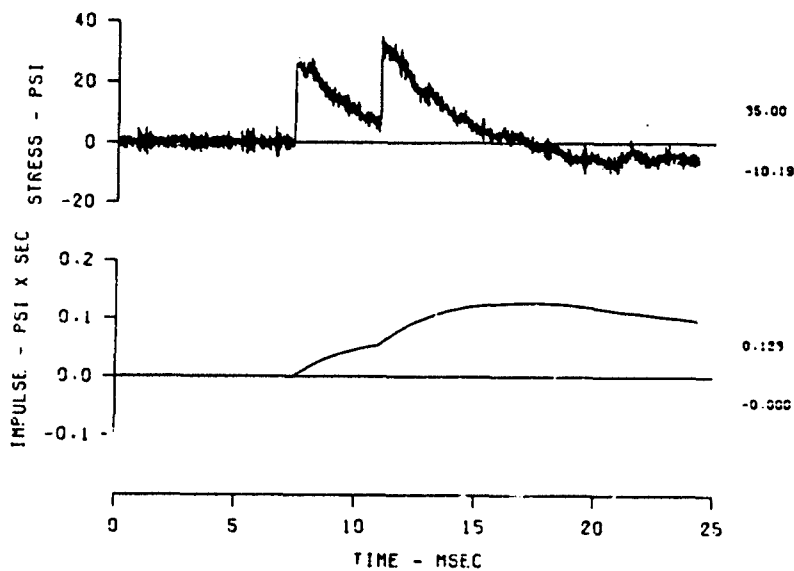


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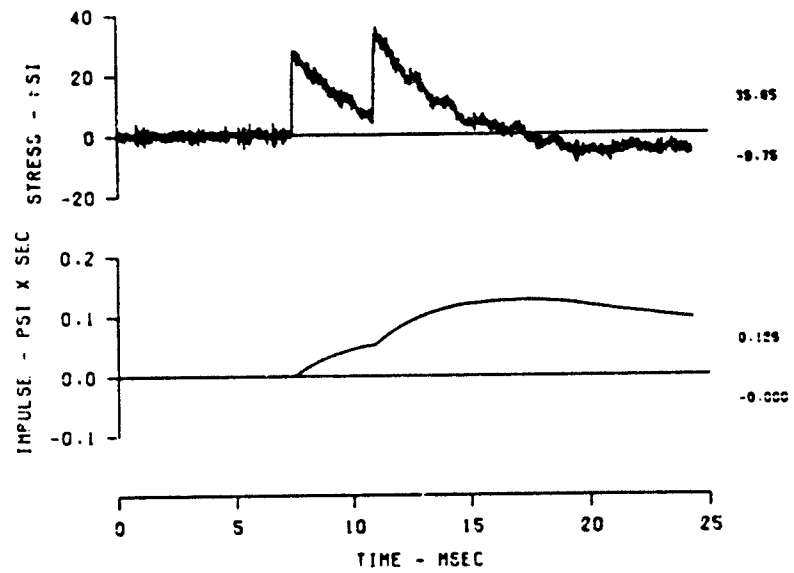
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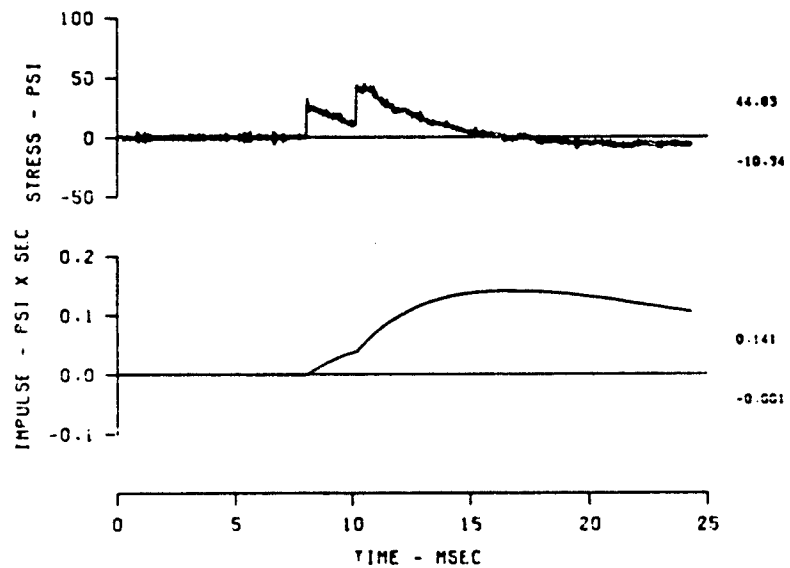
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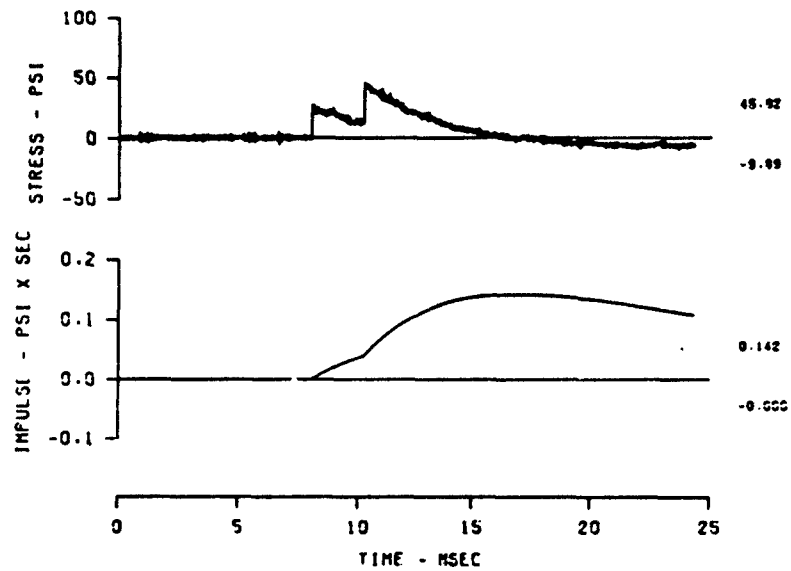
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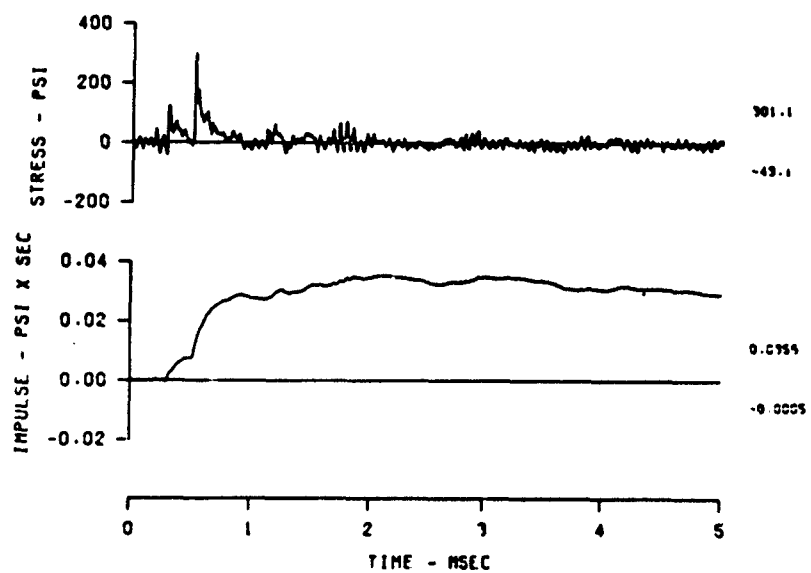
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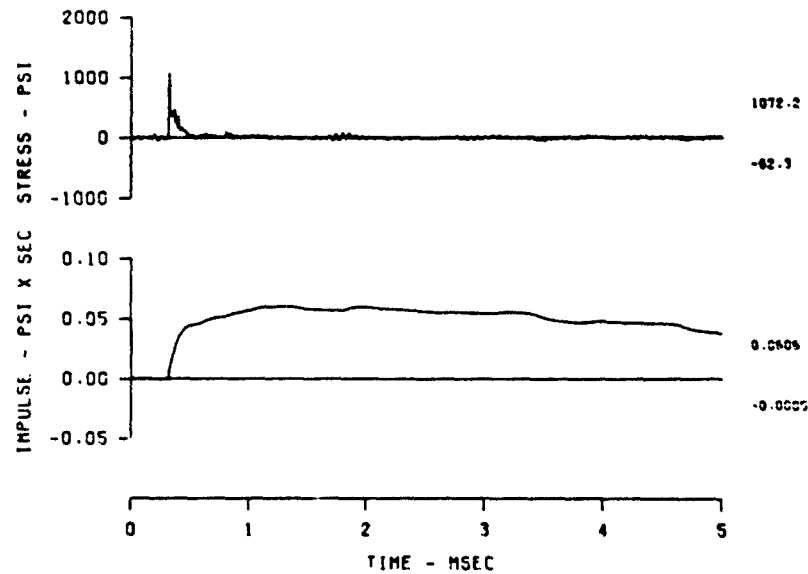
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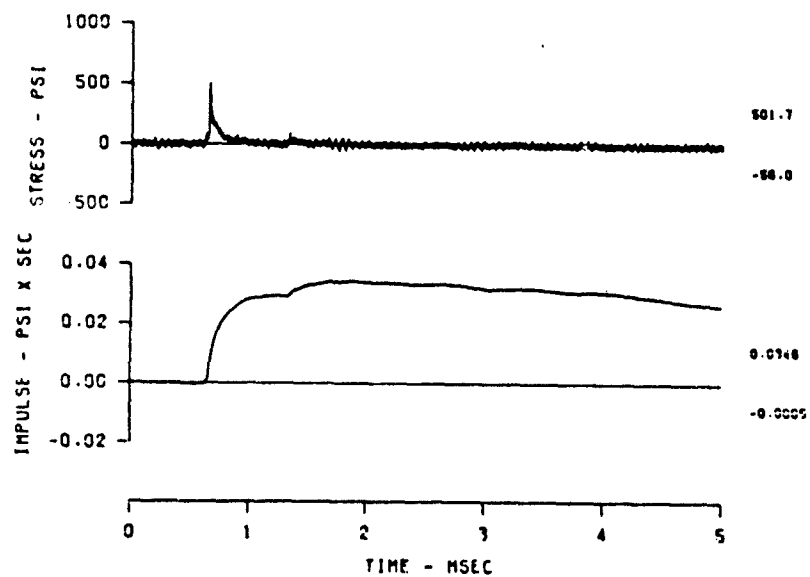
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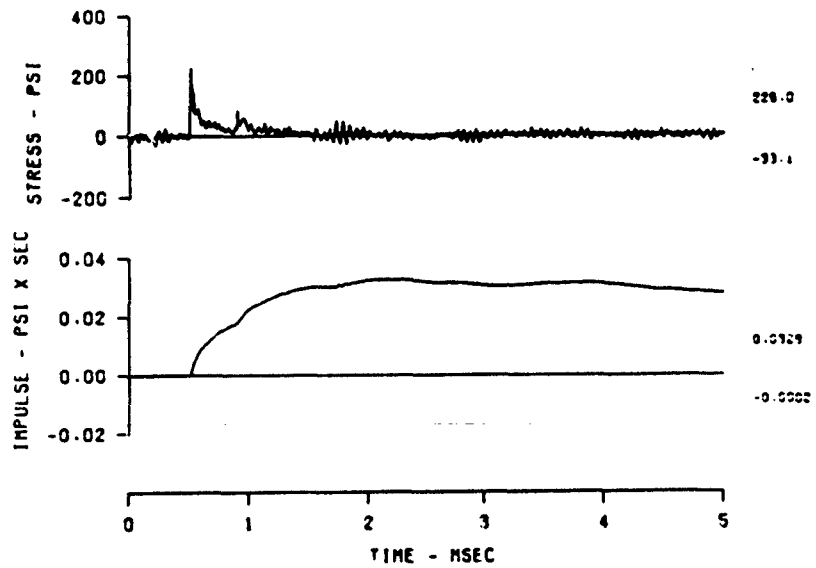
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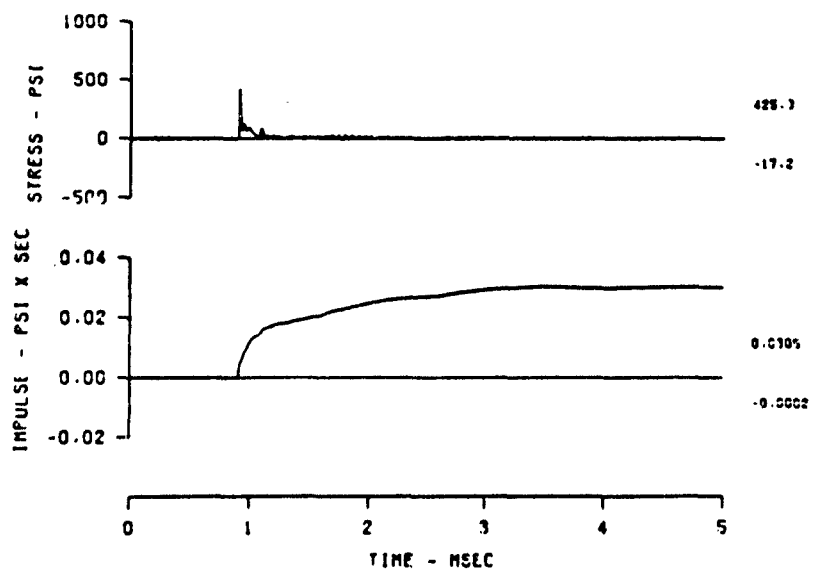
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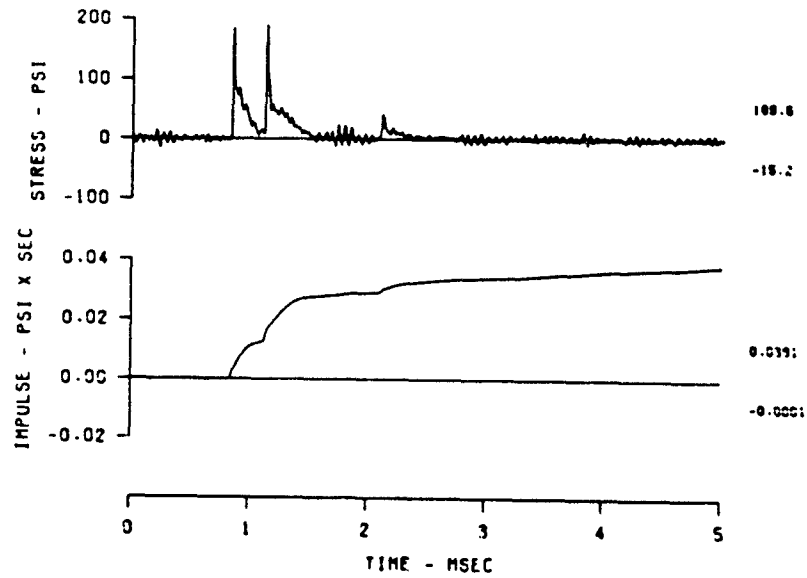
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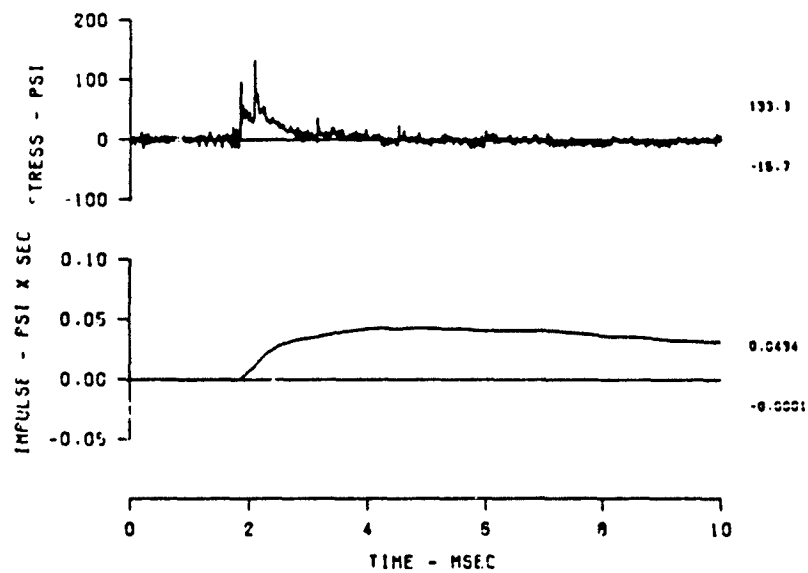
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AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84



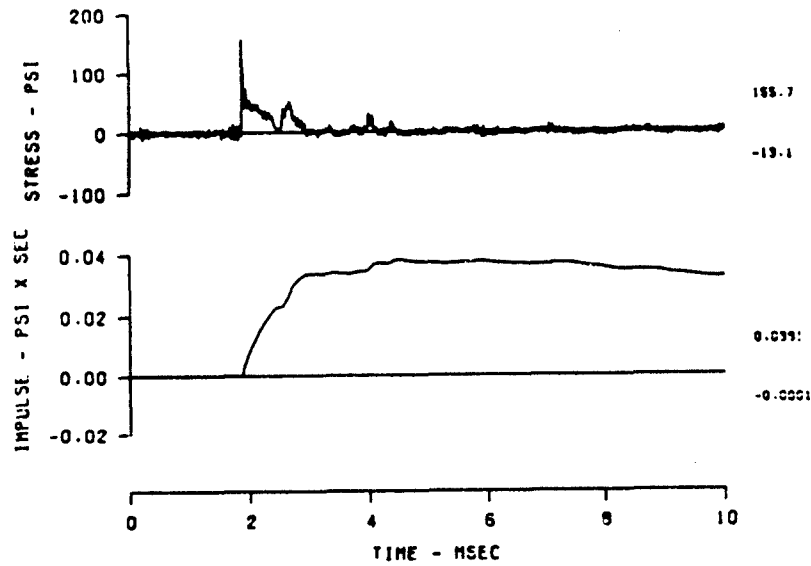
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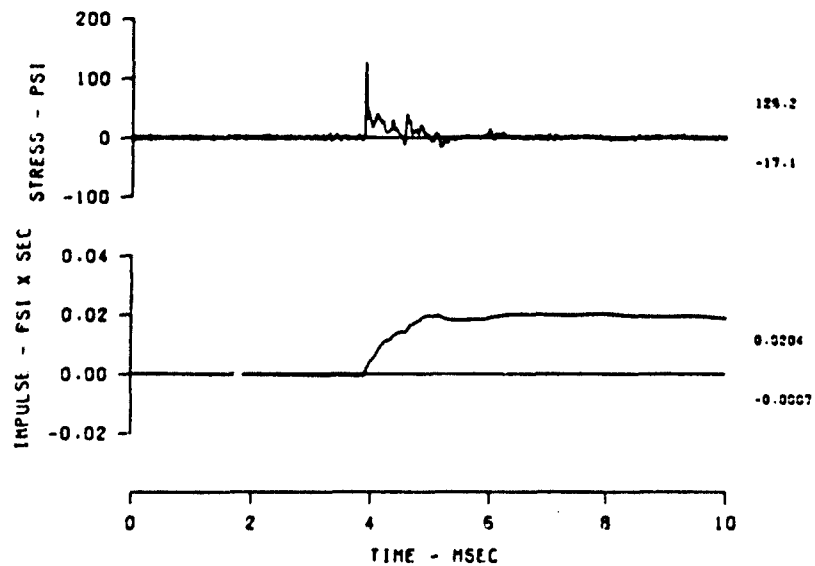
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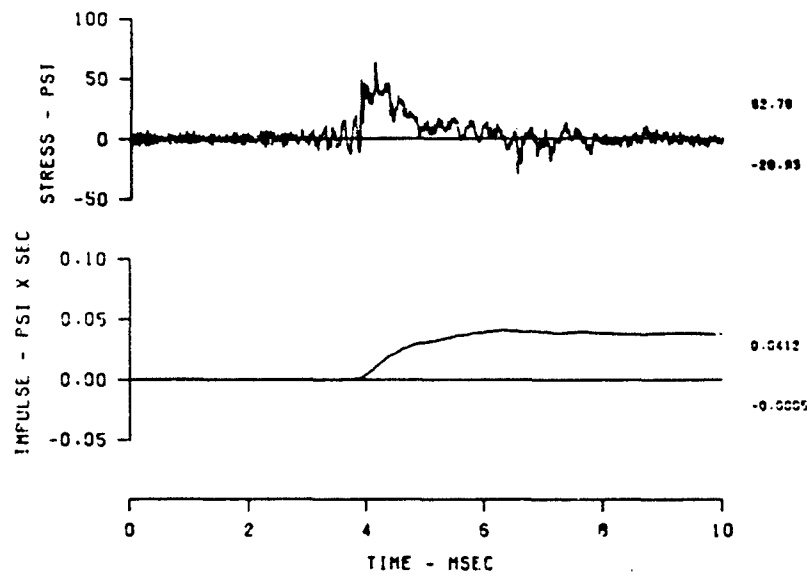
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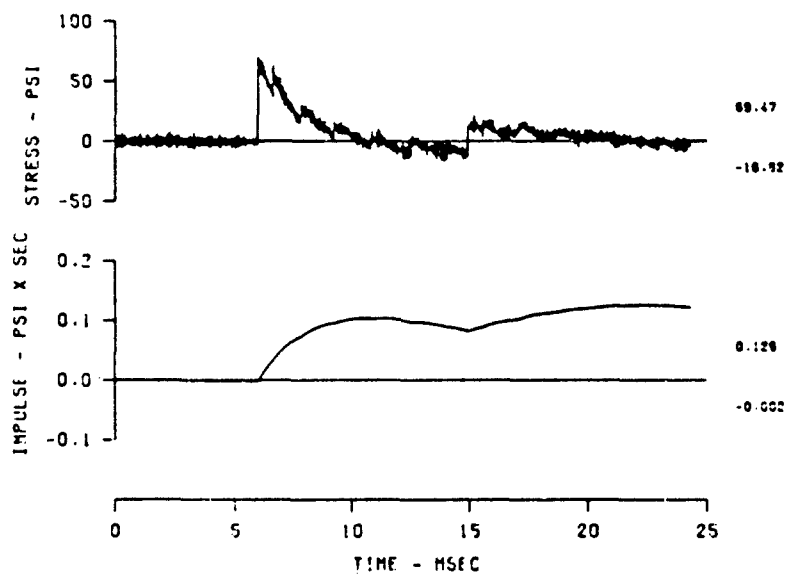
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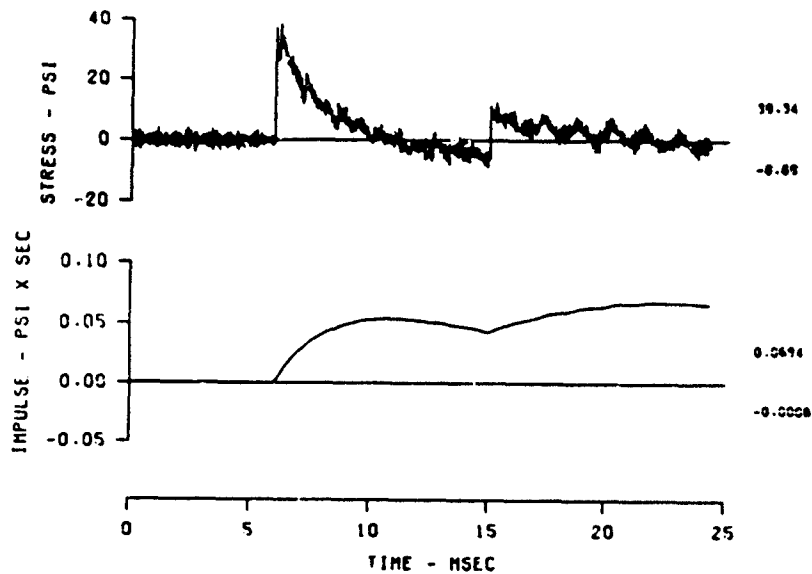
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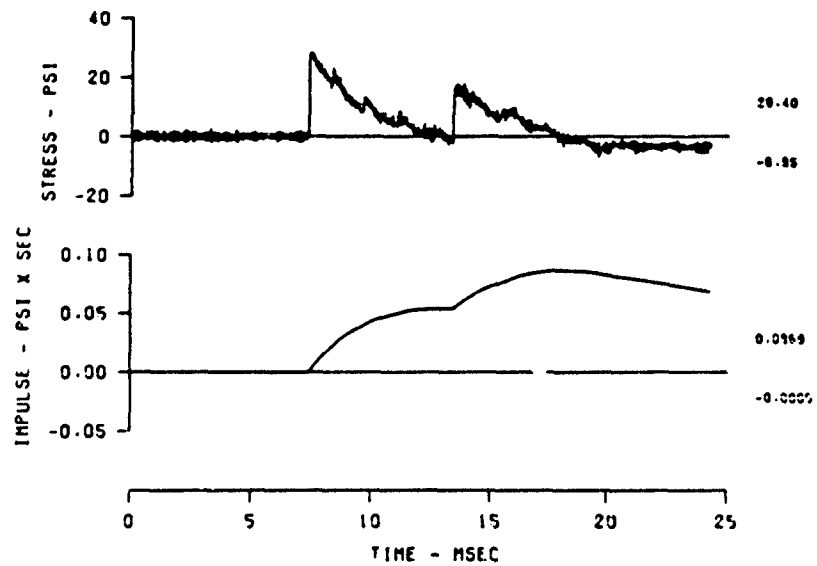
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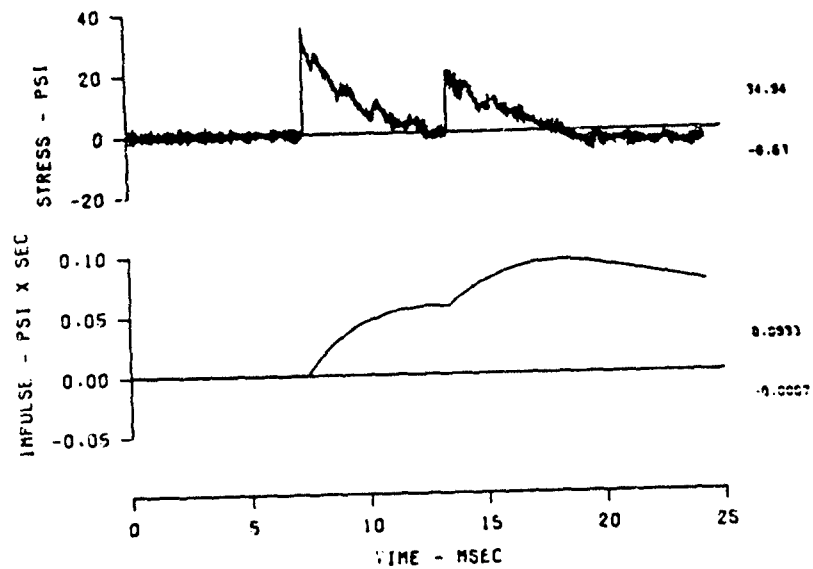
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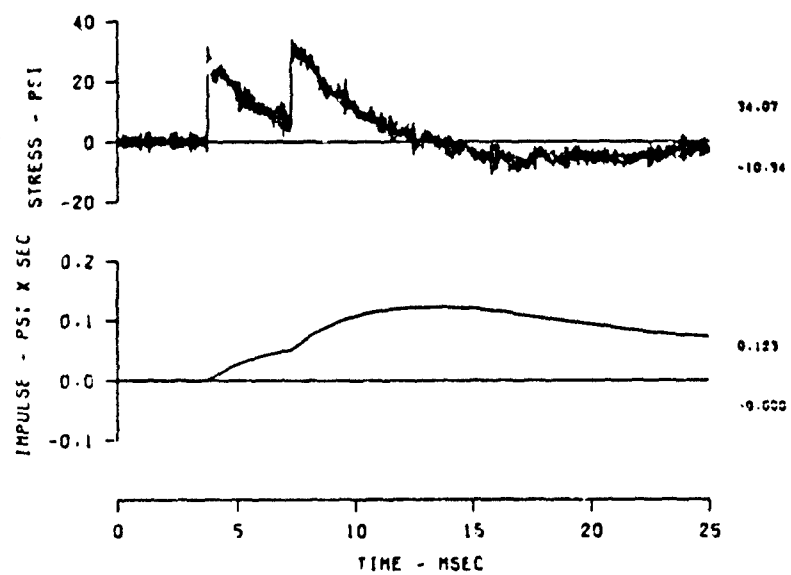
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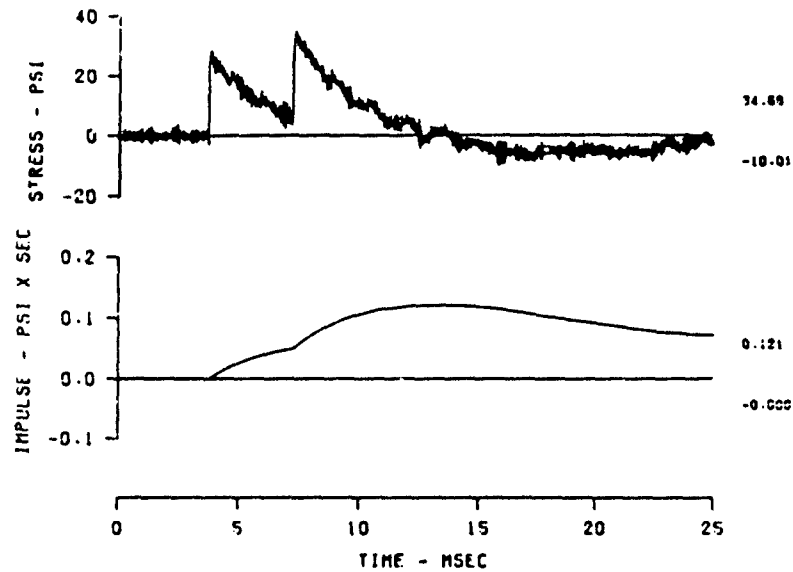
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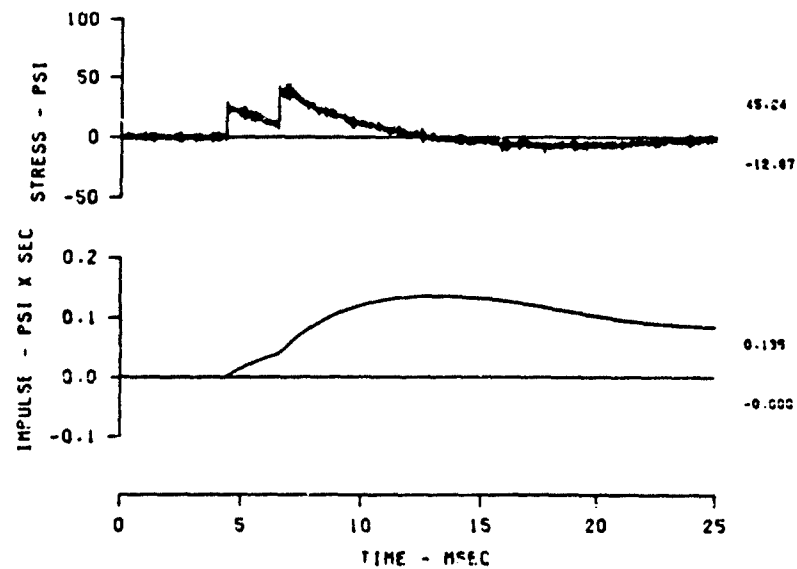
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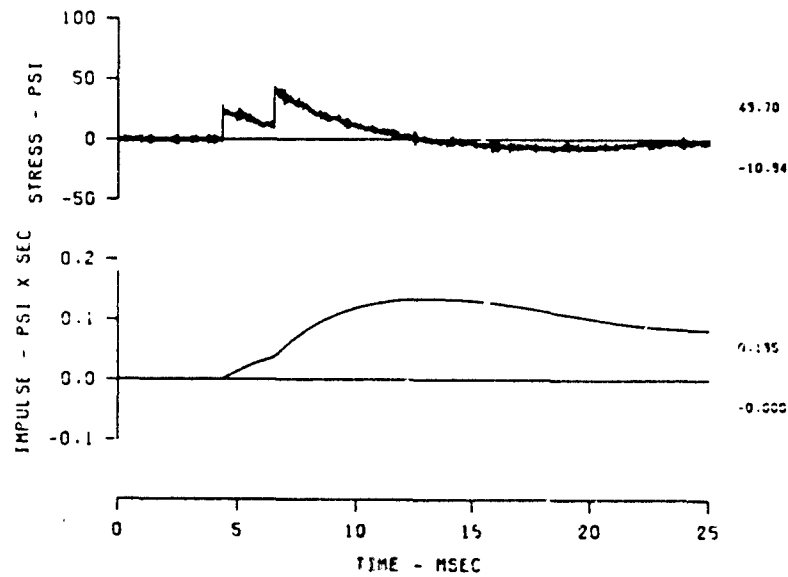
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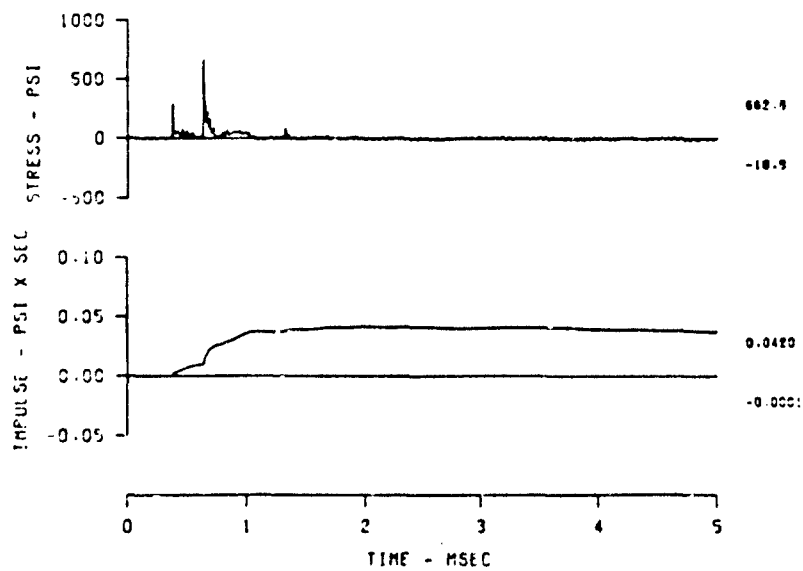
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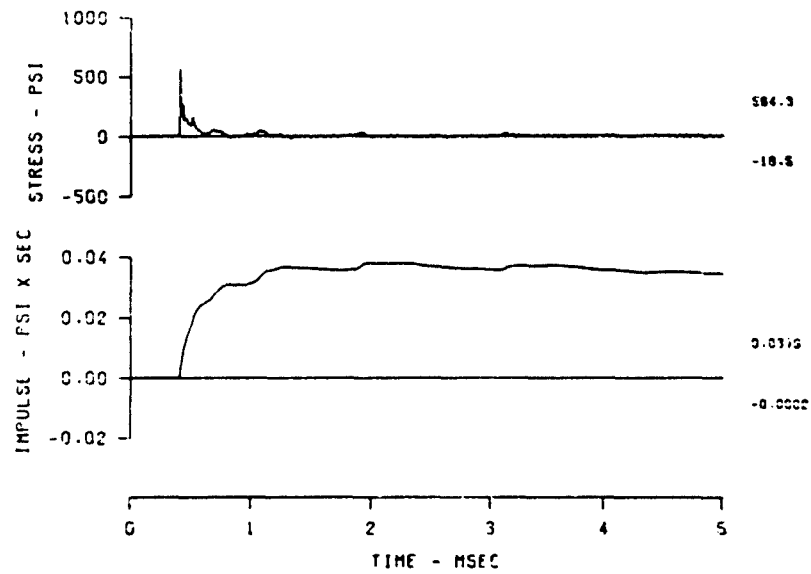
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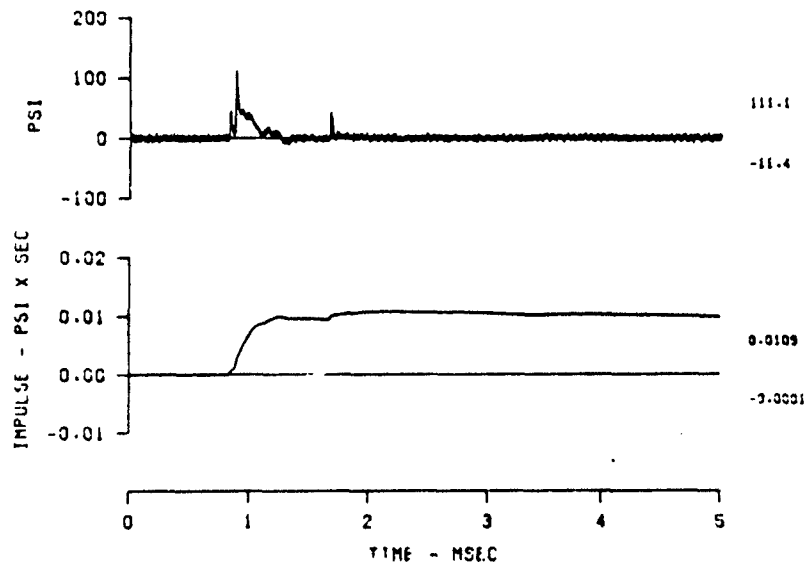
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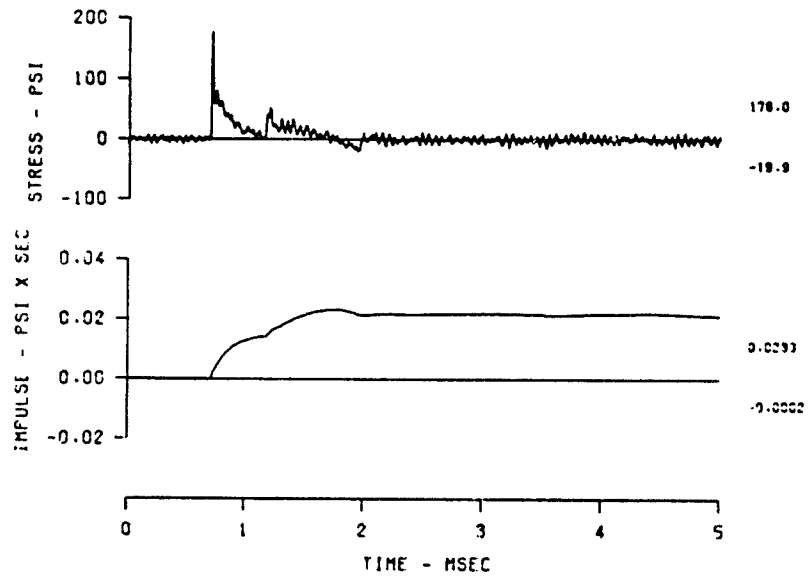
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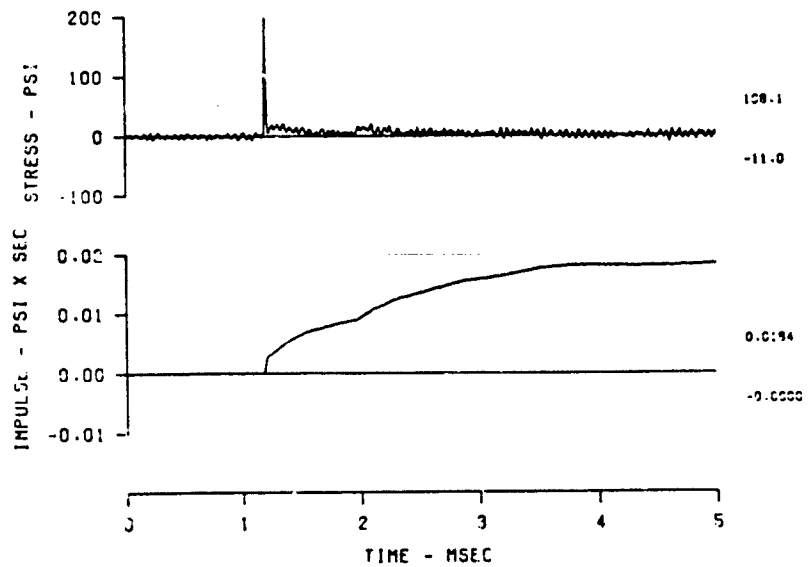
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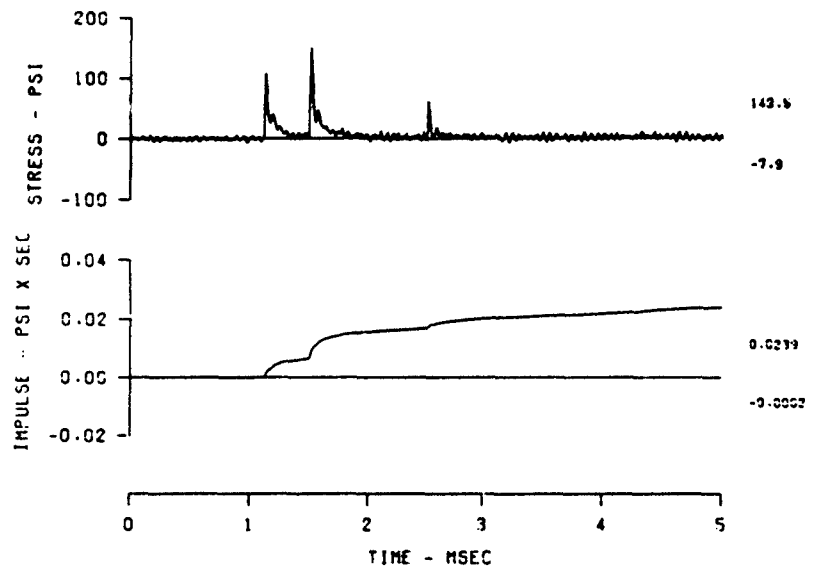
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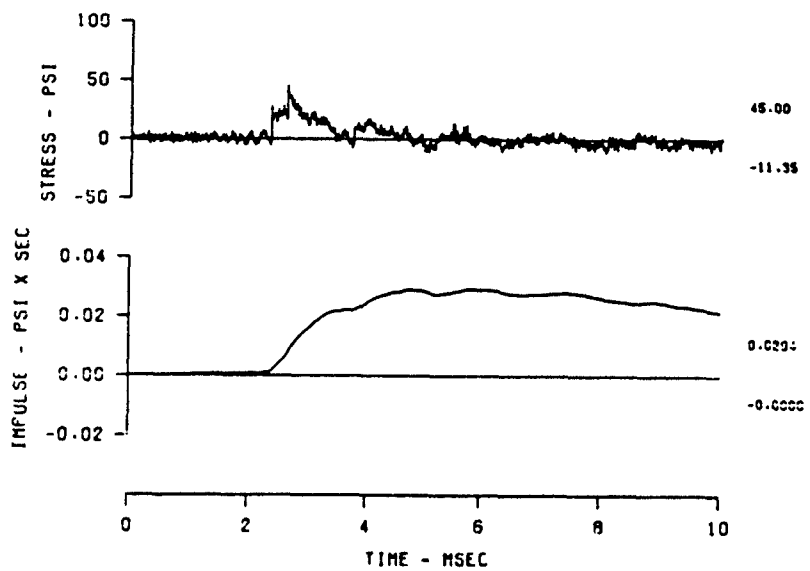
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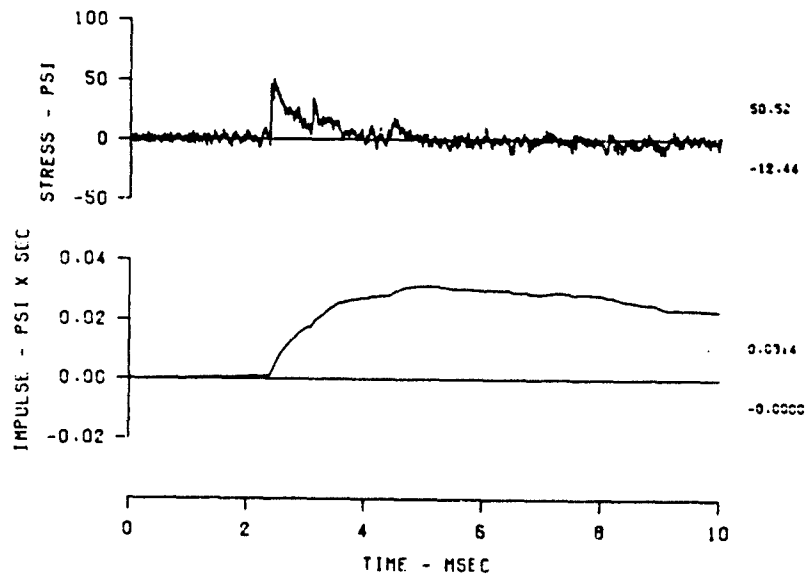
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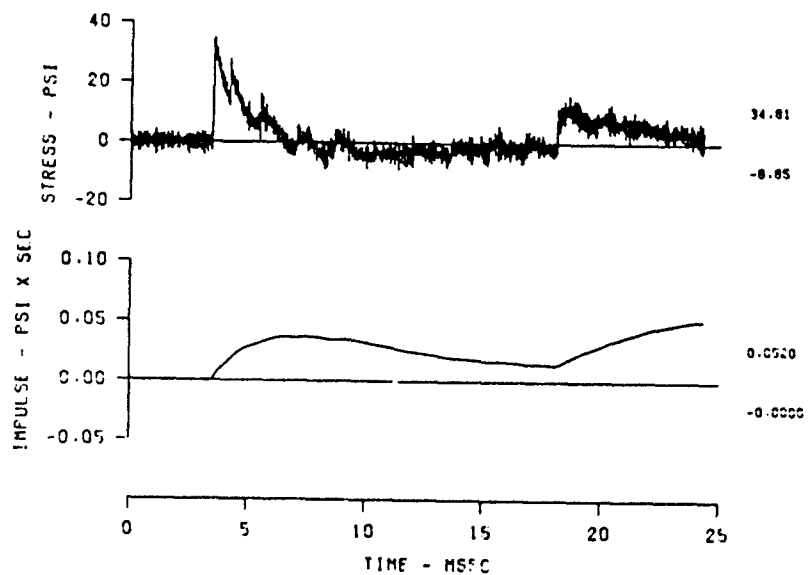
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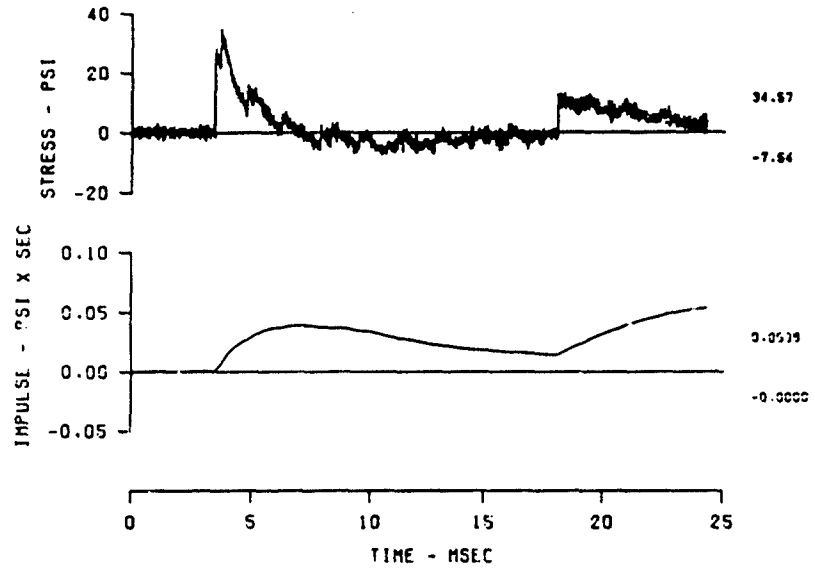
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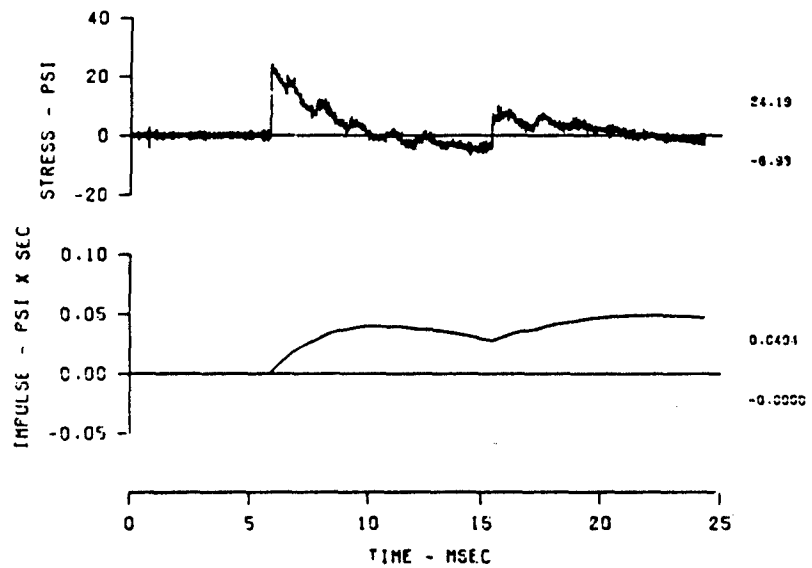
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SHOT 7 CH 11 10
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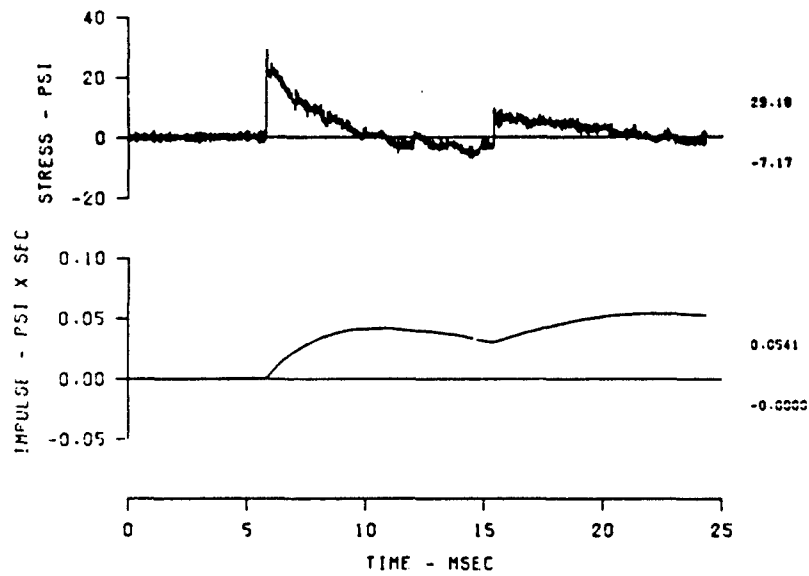


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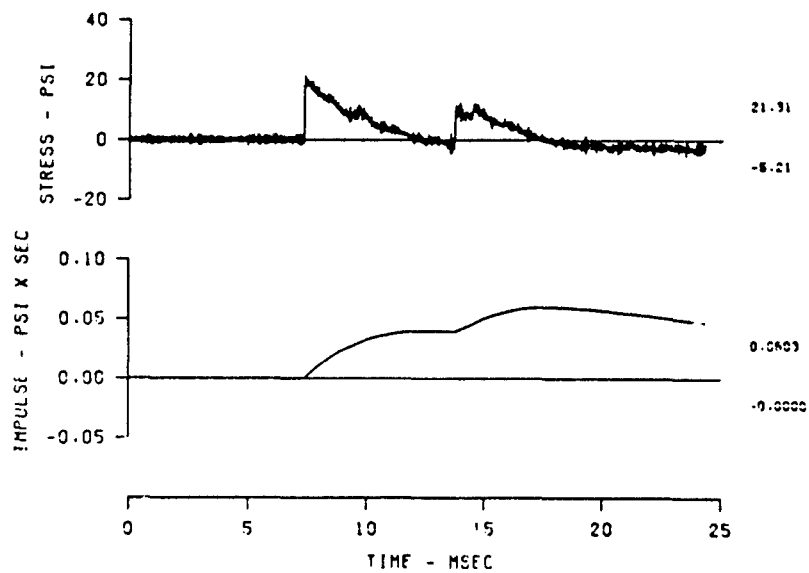


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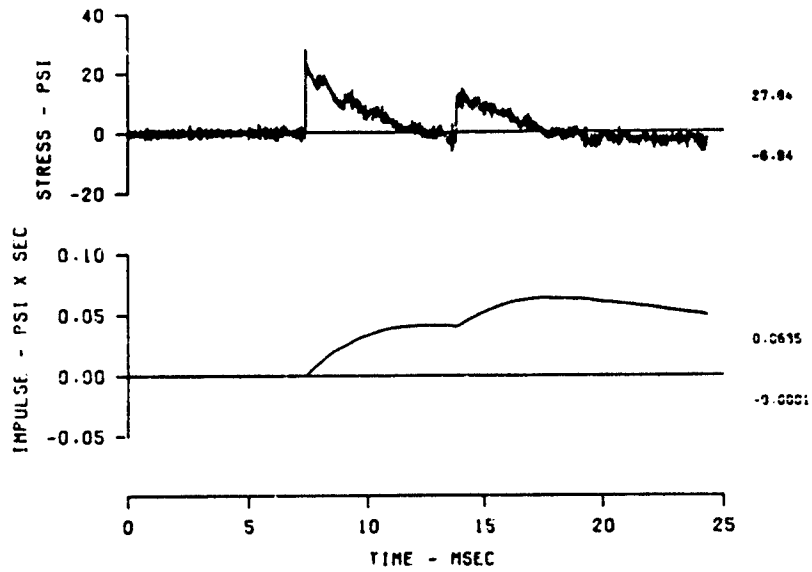
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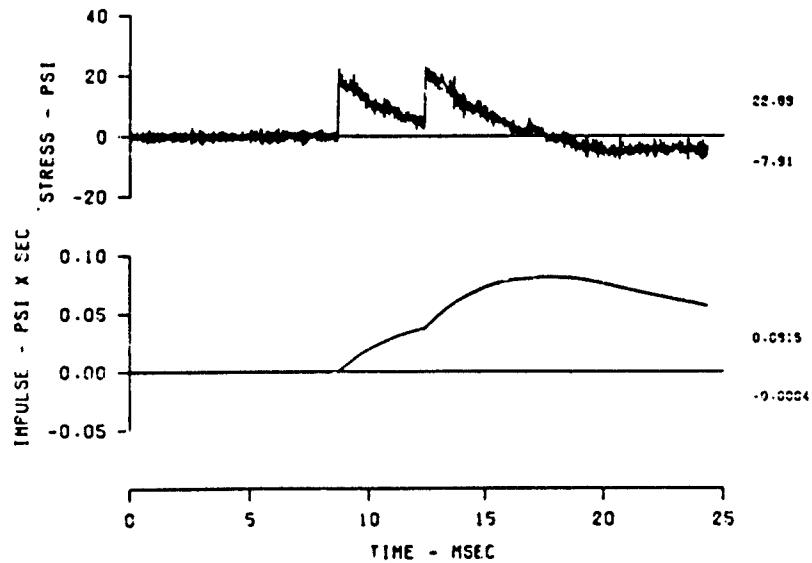
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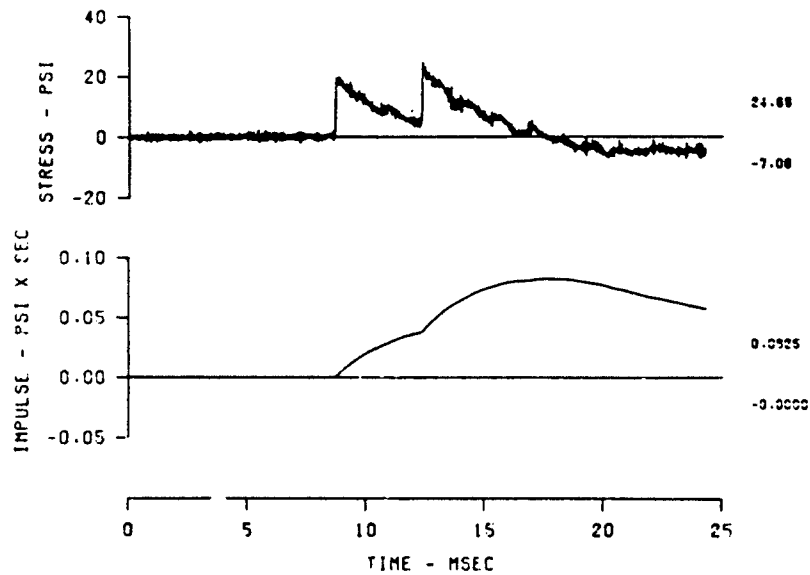
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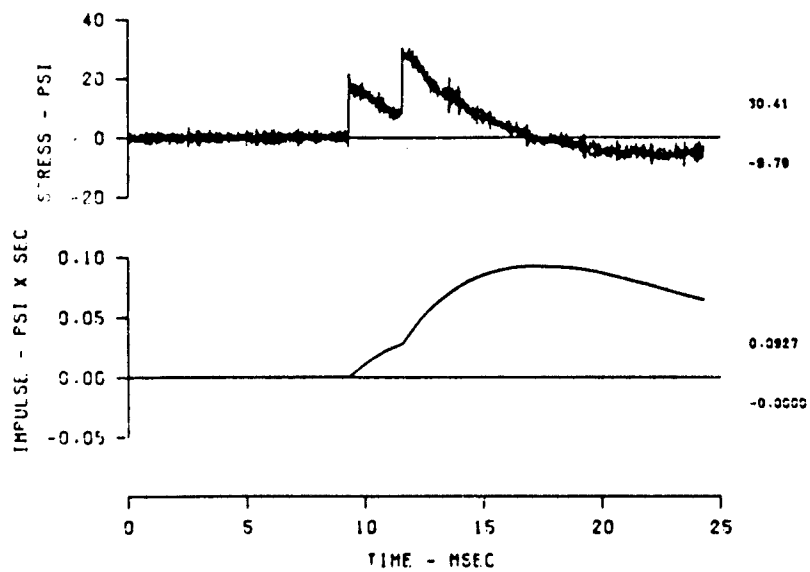
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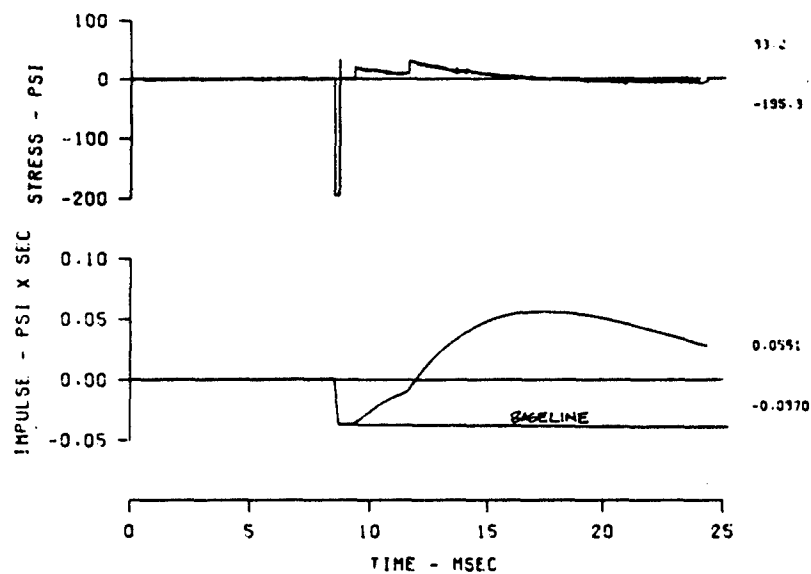
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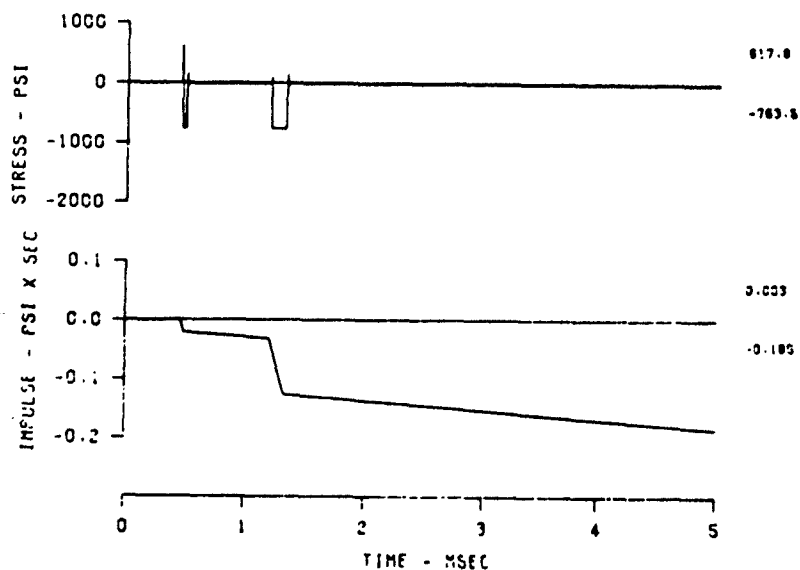
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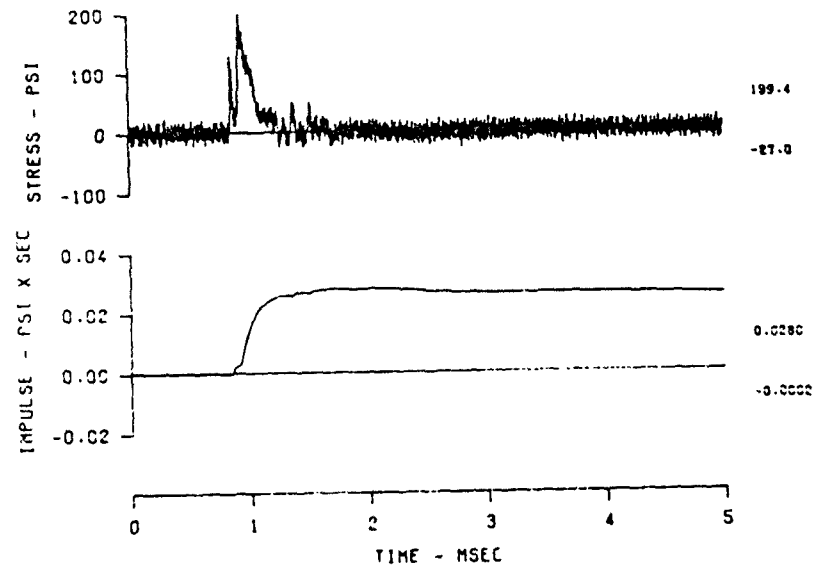
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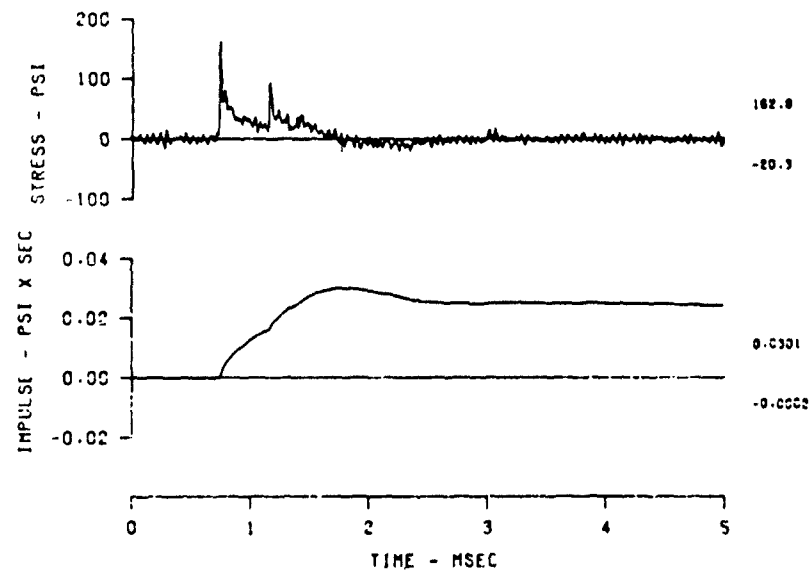
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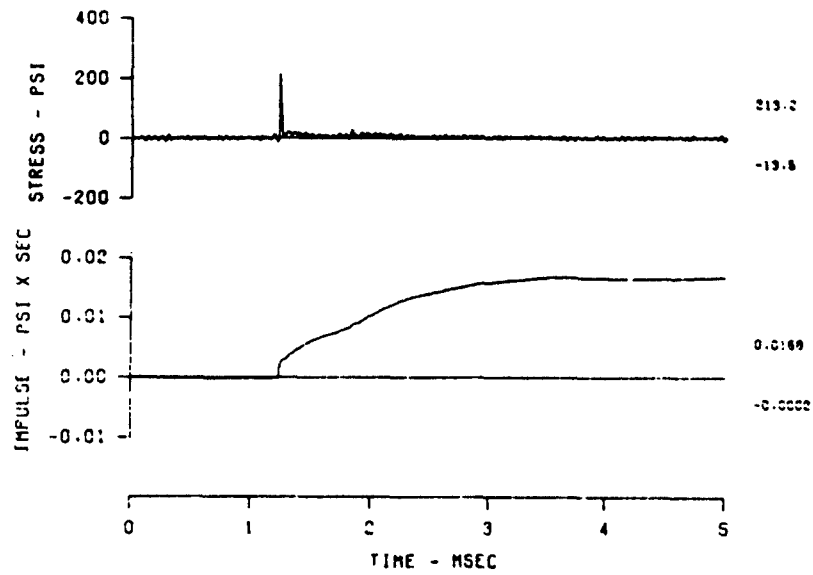
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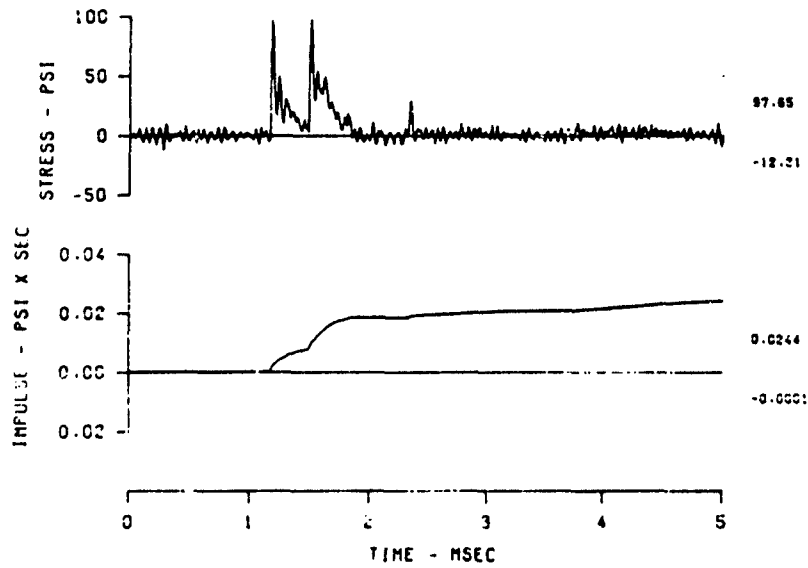
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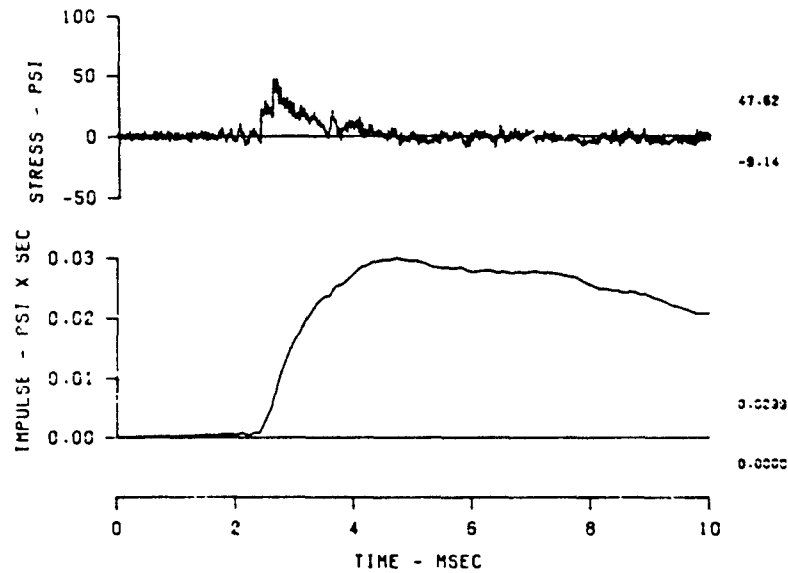
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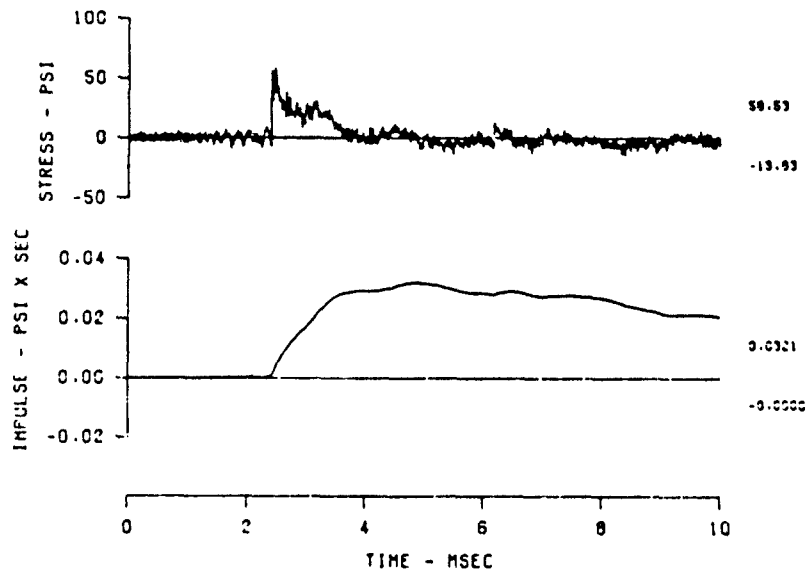
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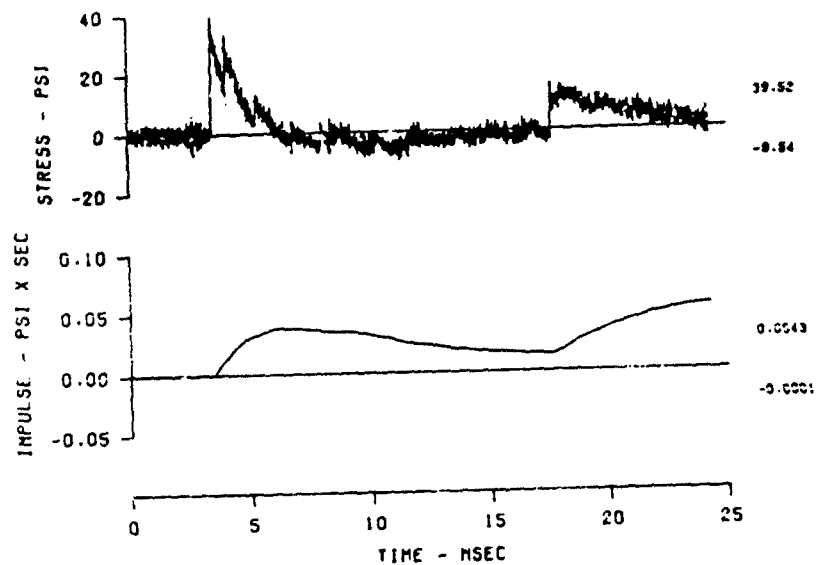
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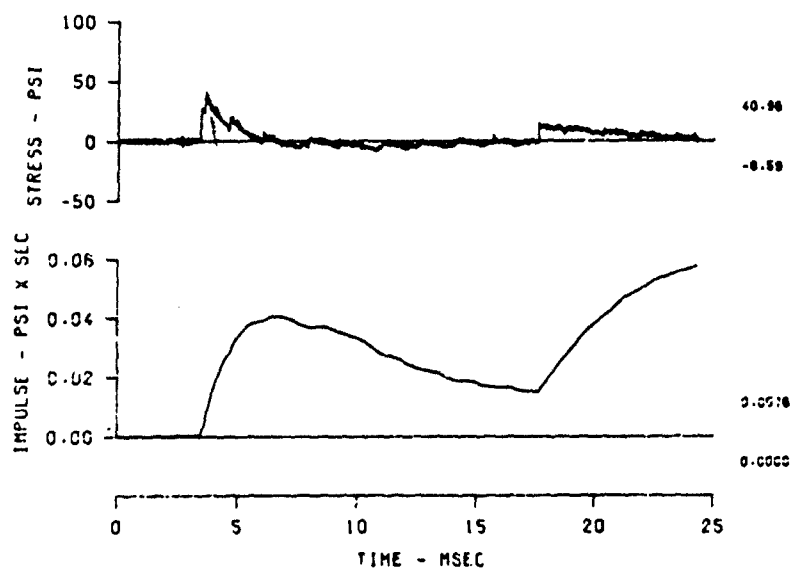
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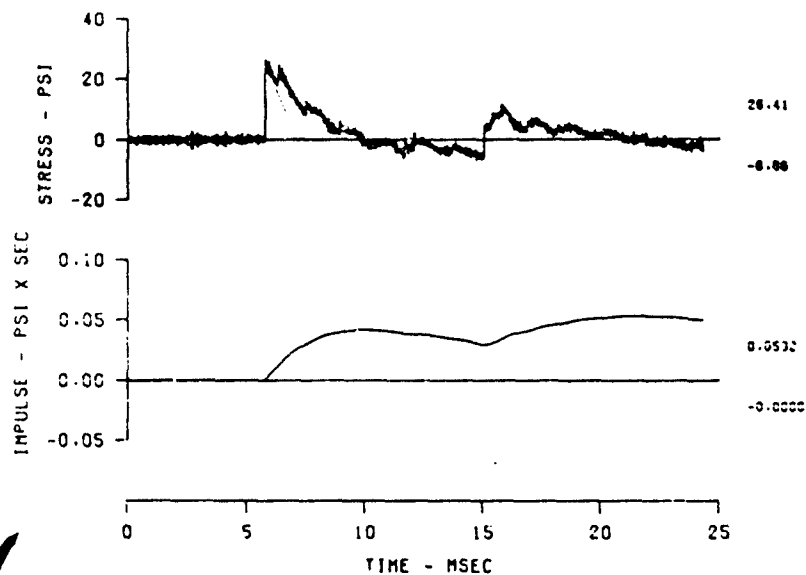
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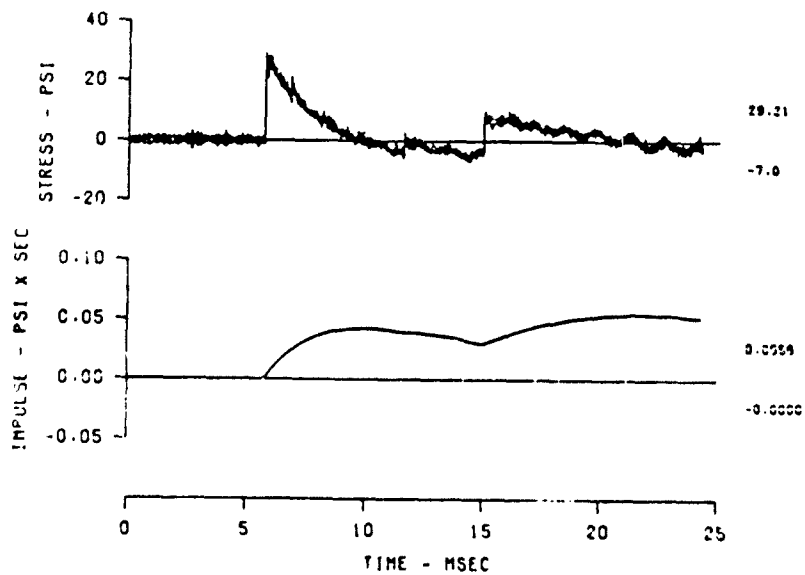
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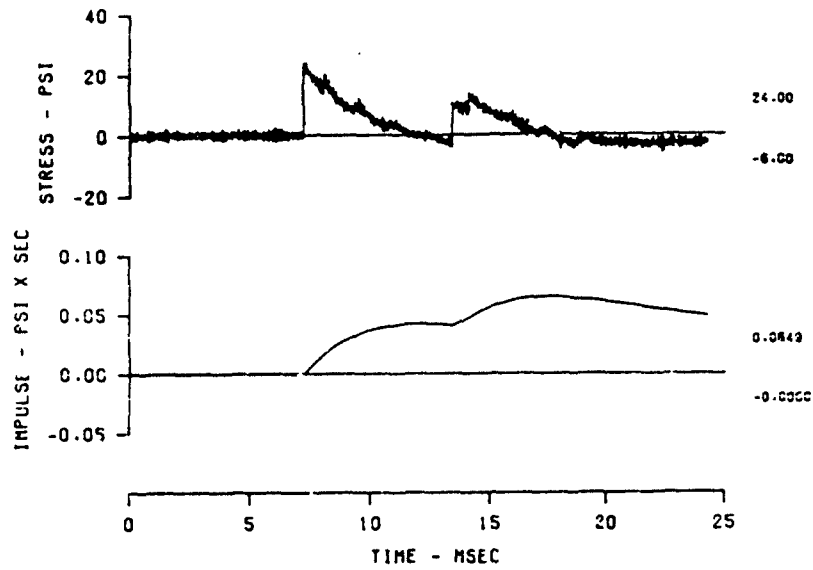
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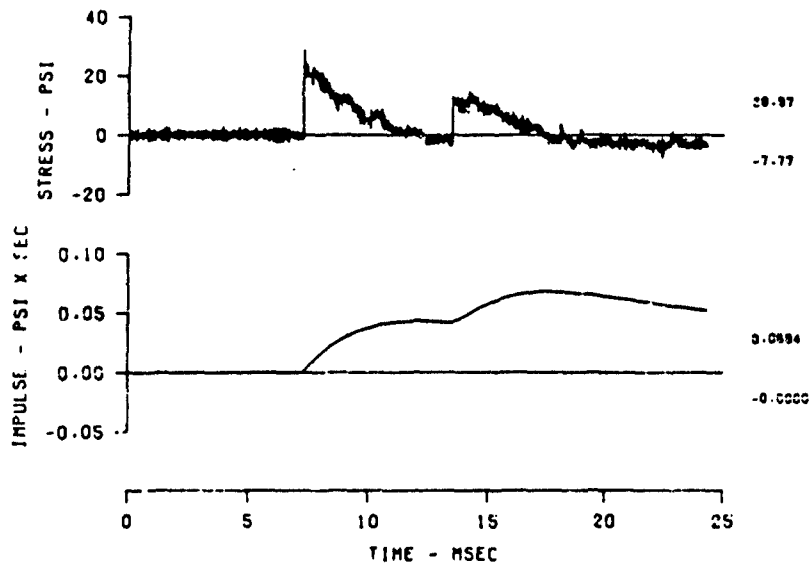
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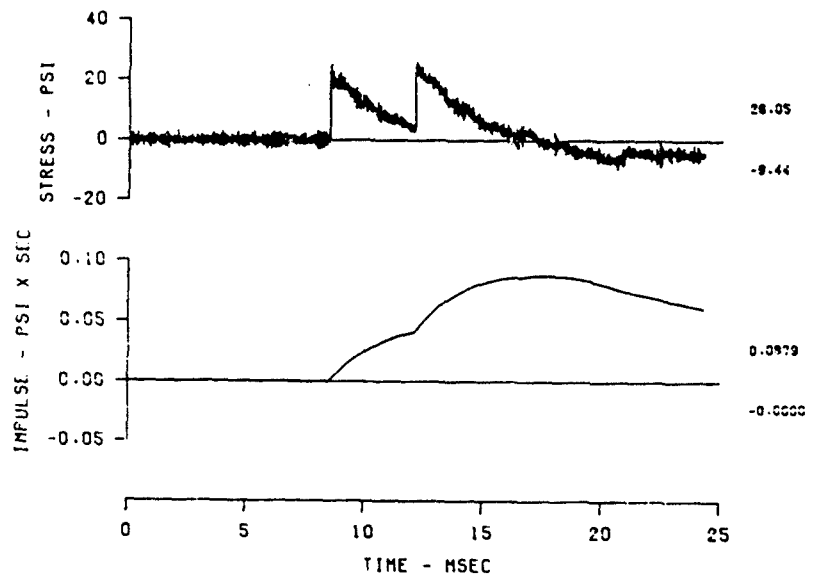
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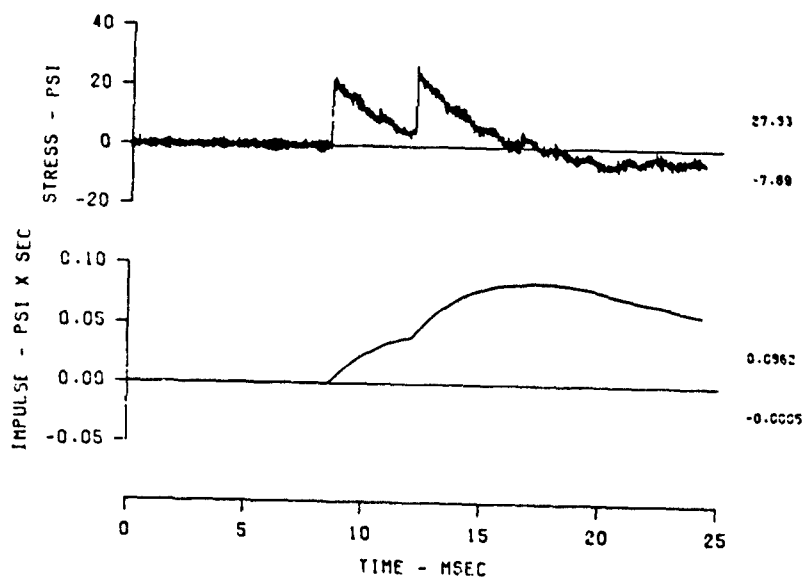
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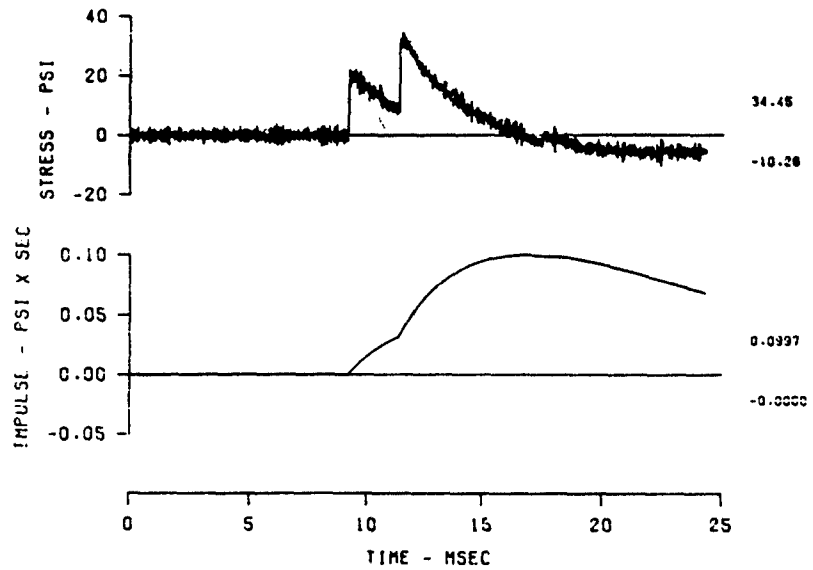
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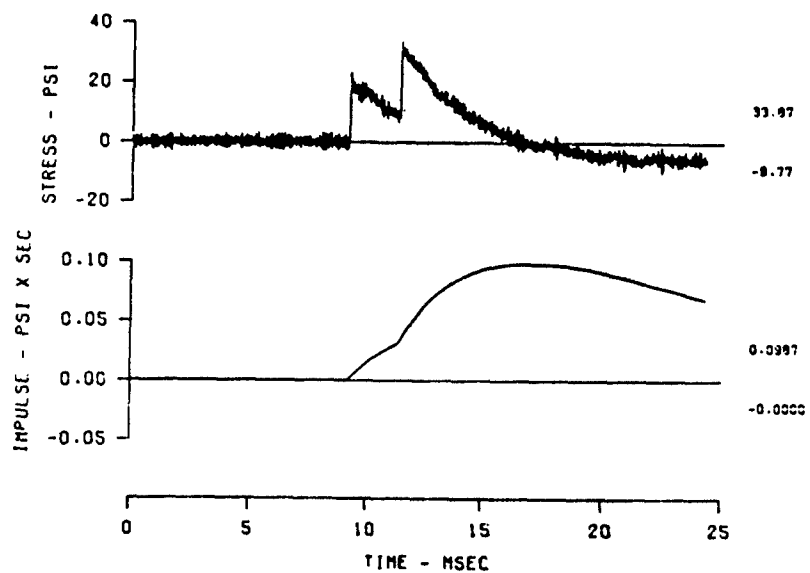
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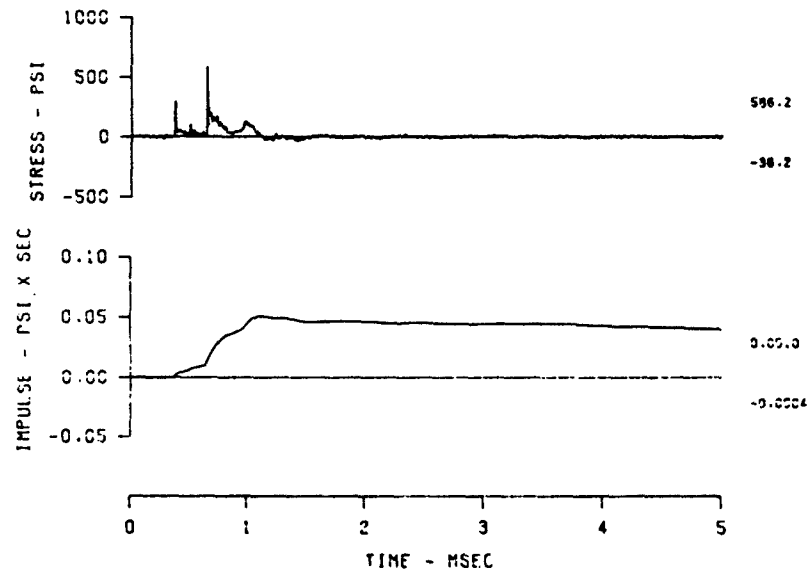
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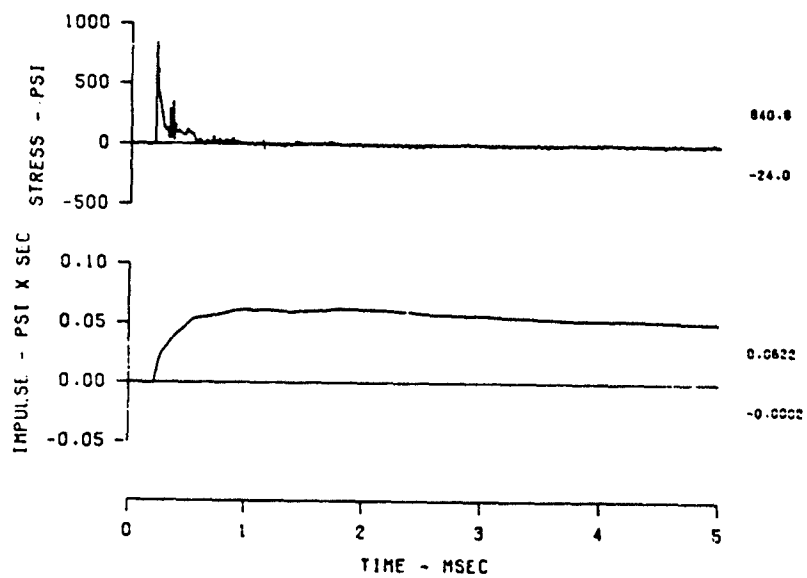
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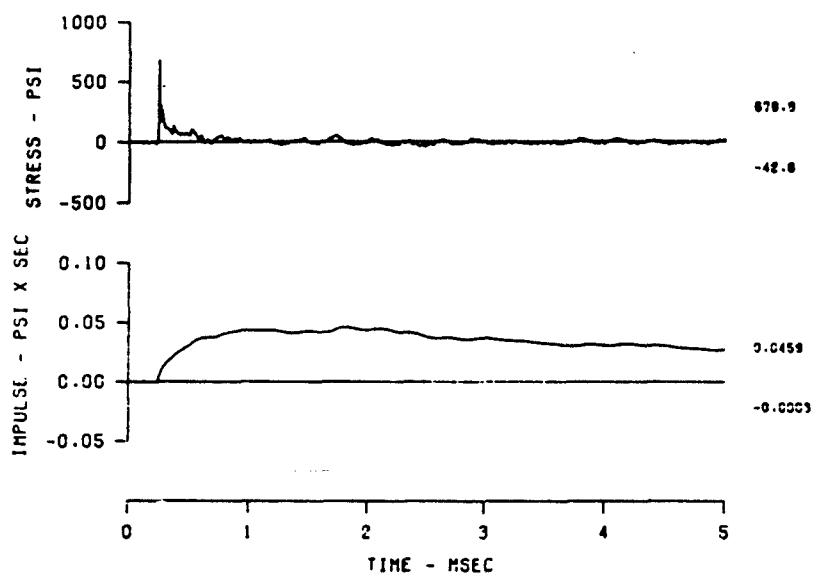
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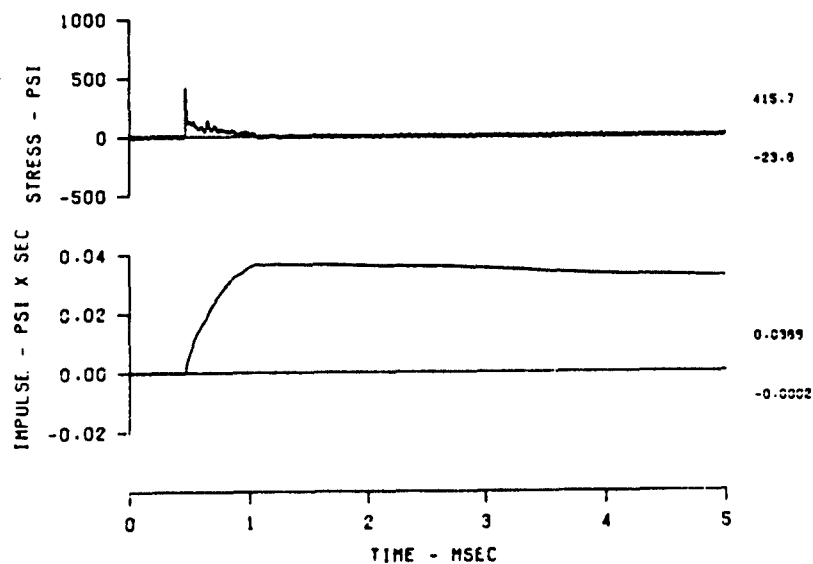
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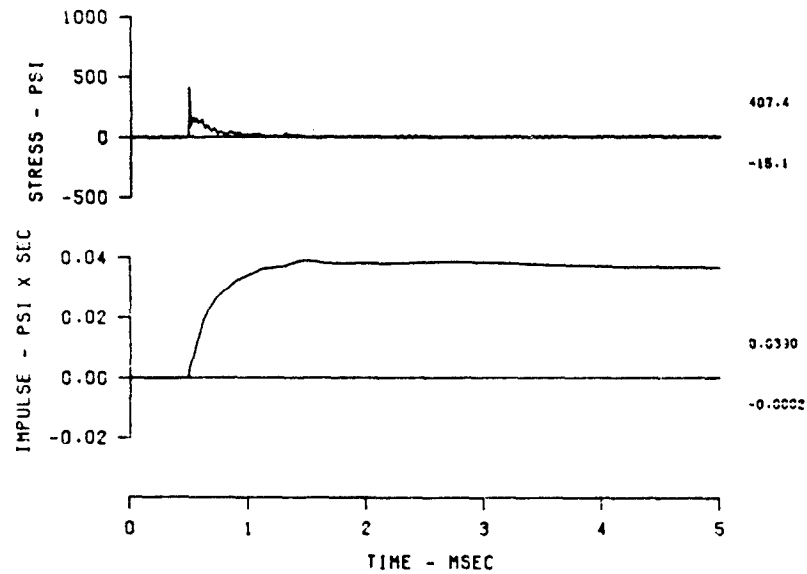
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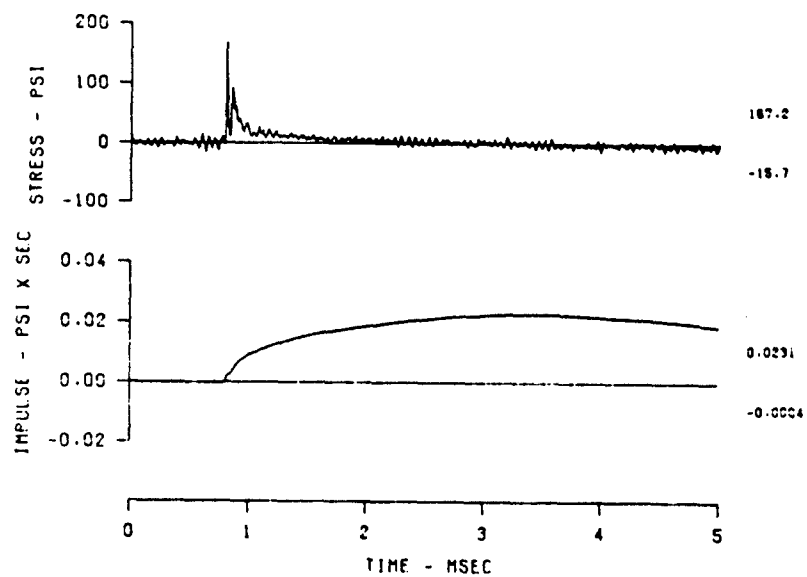
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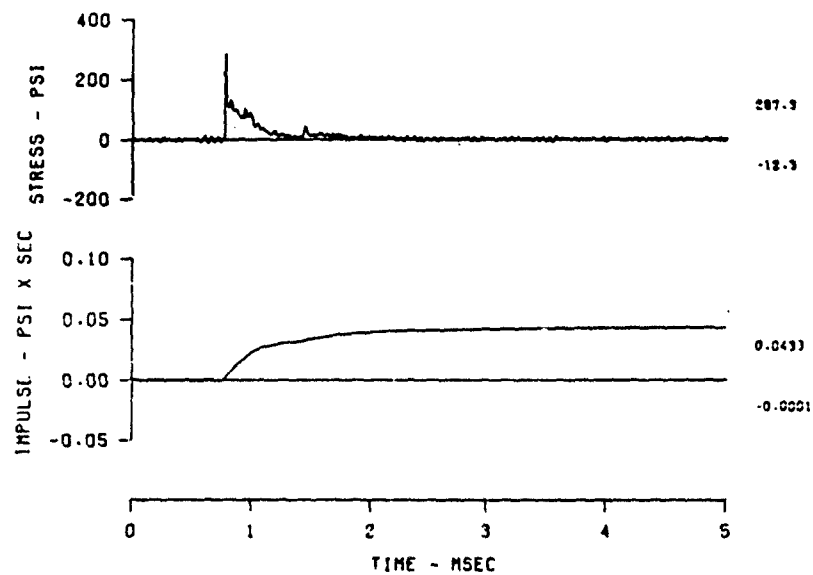
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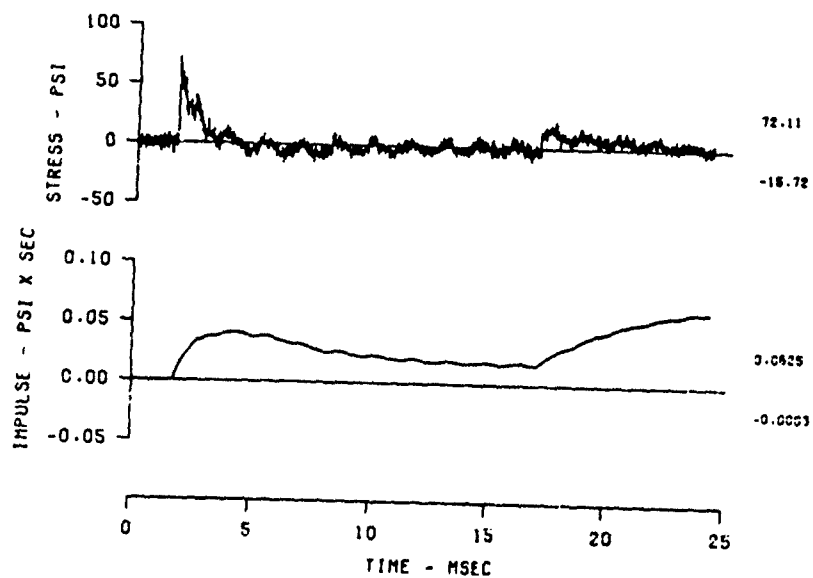
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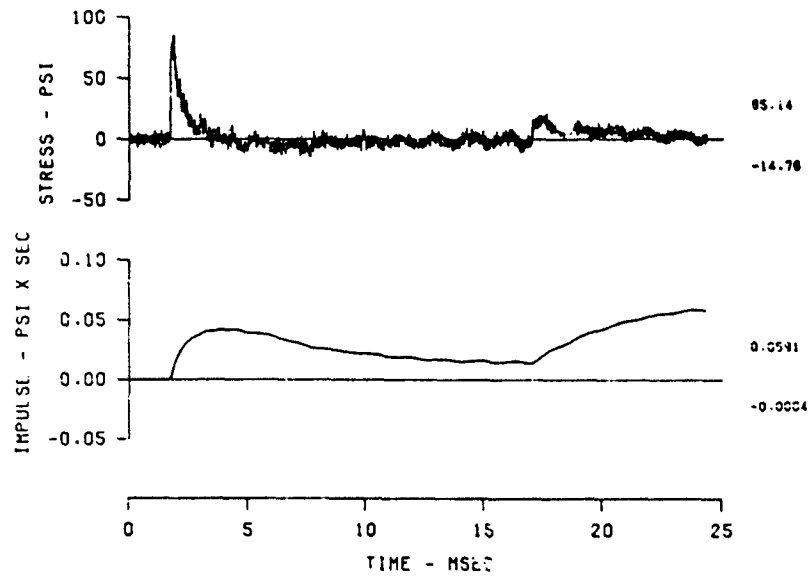
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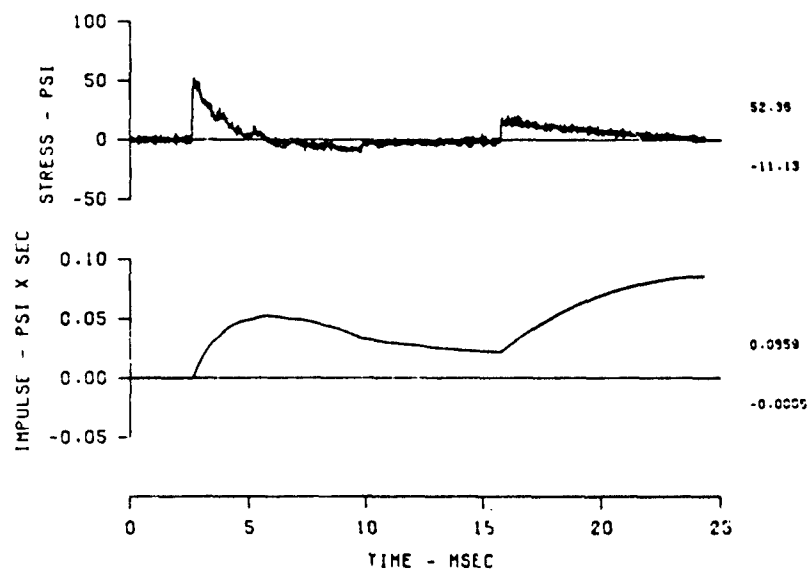
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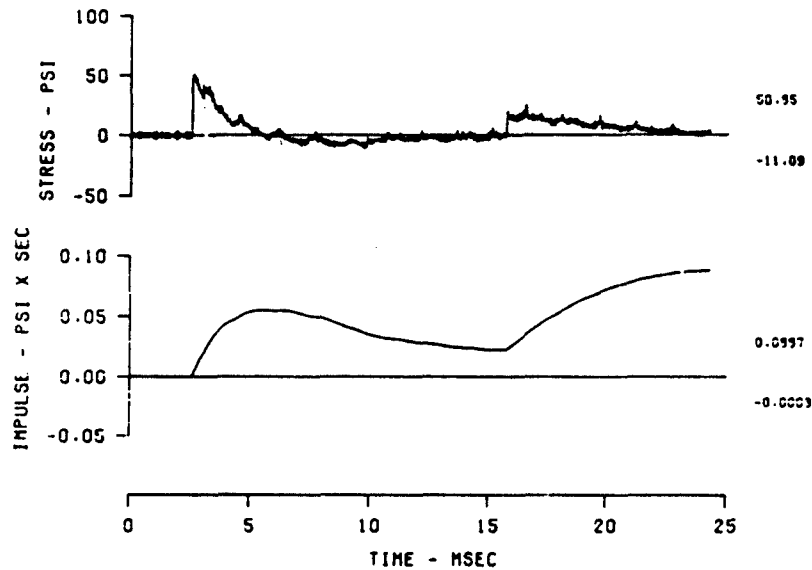
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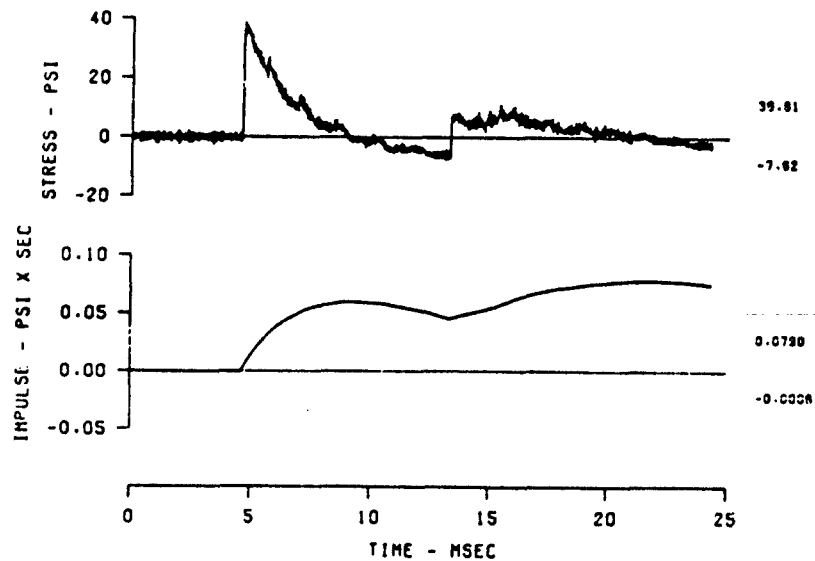
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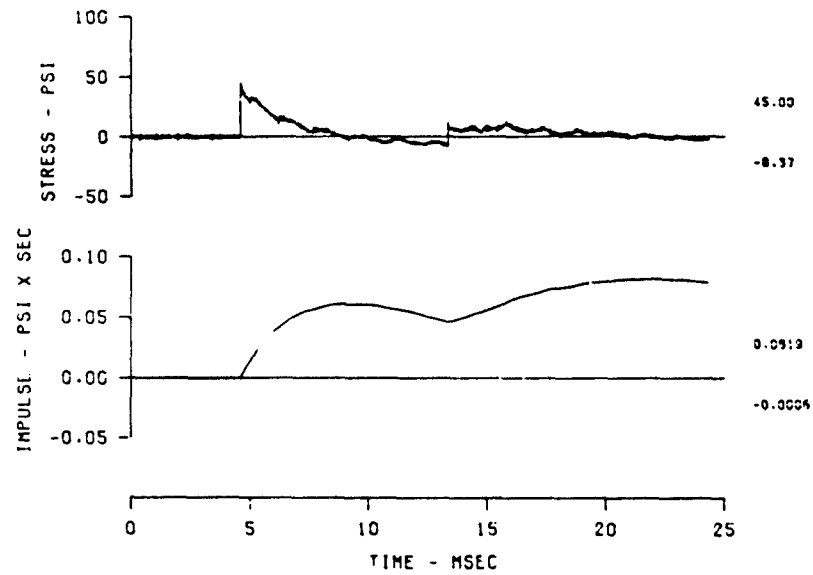
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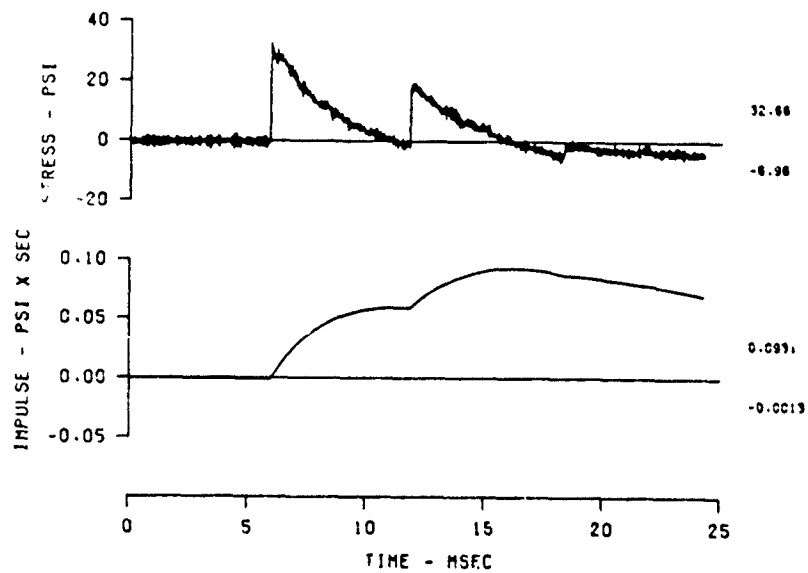
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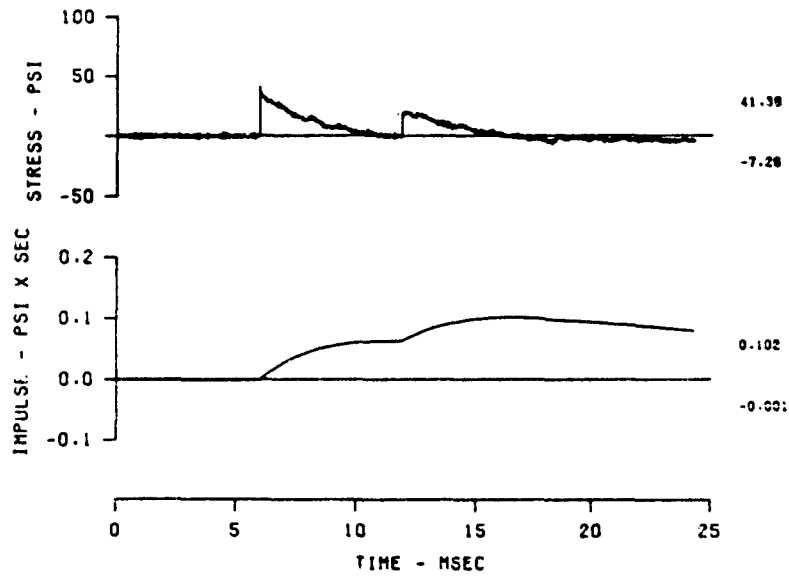
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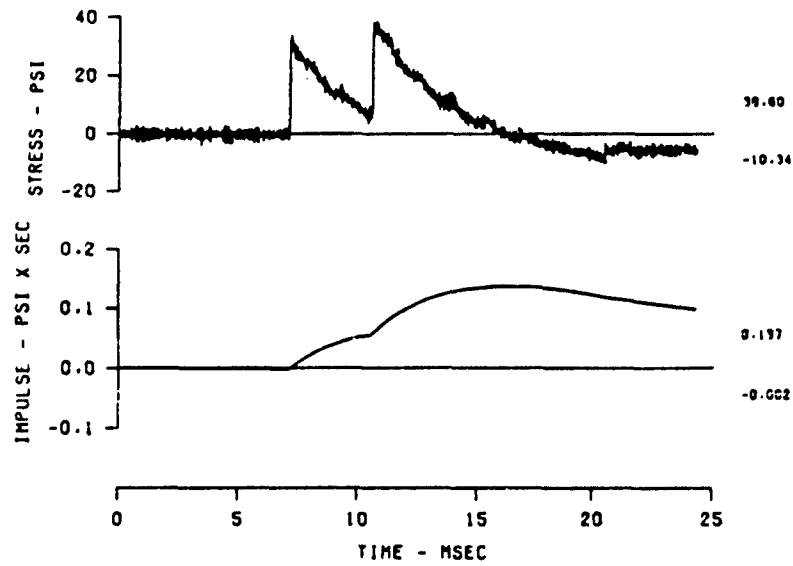
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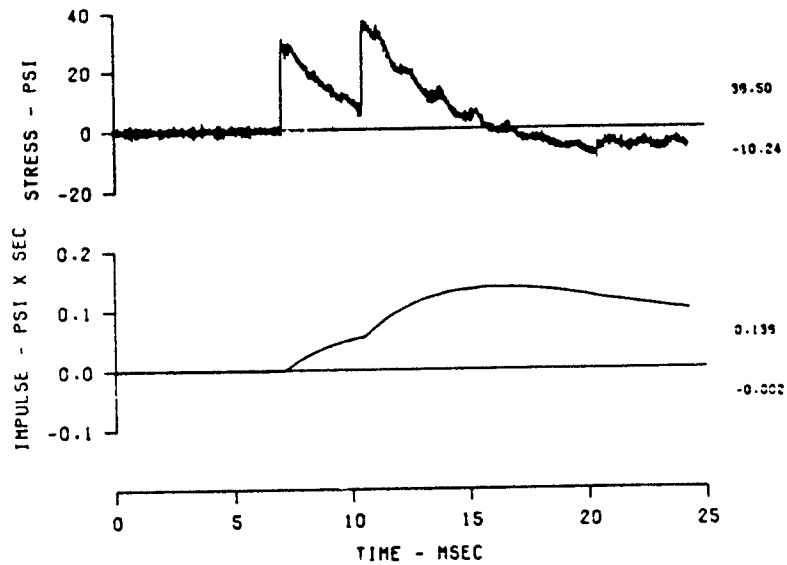
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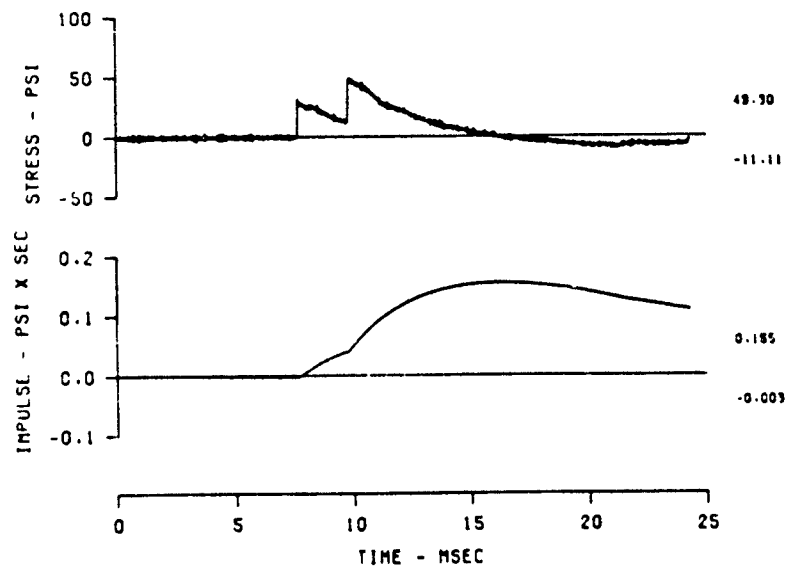
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SHOT 9 CH 17 16
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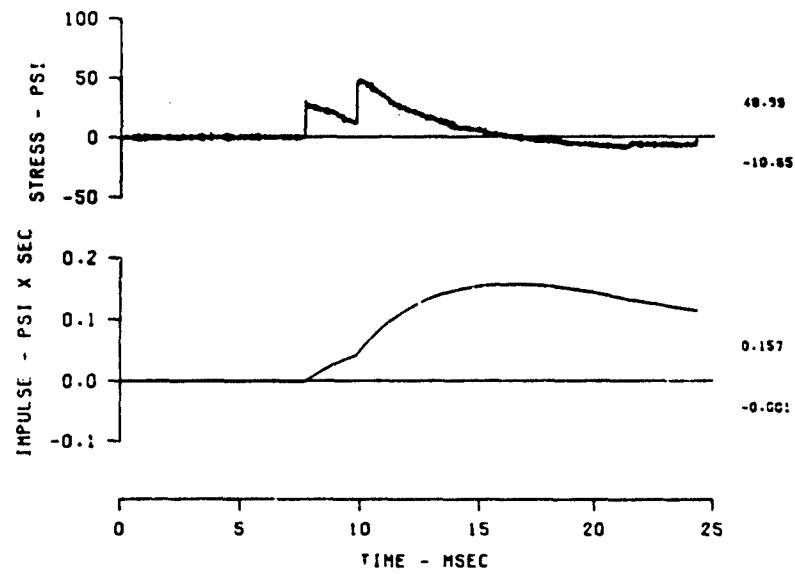


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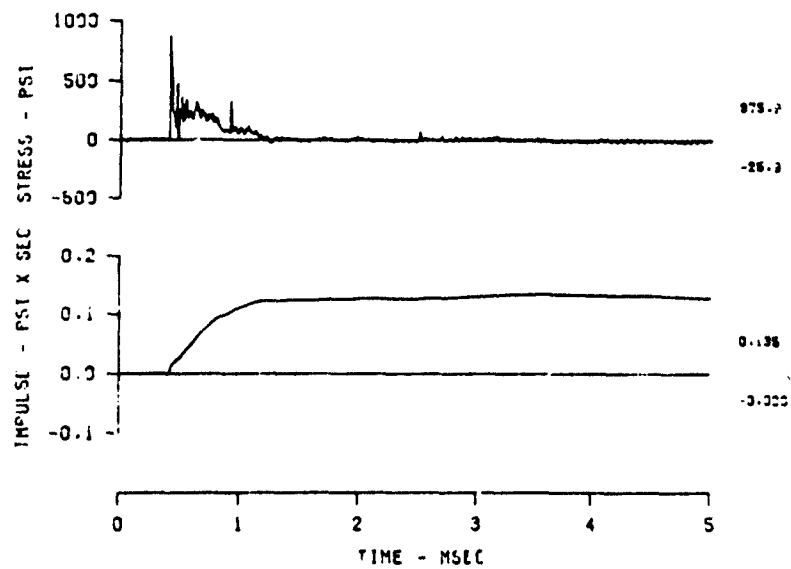


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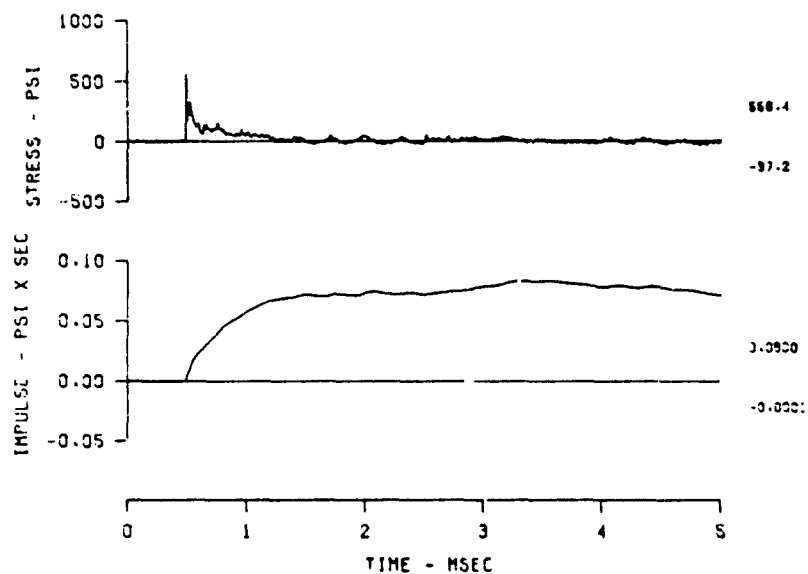
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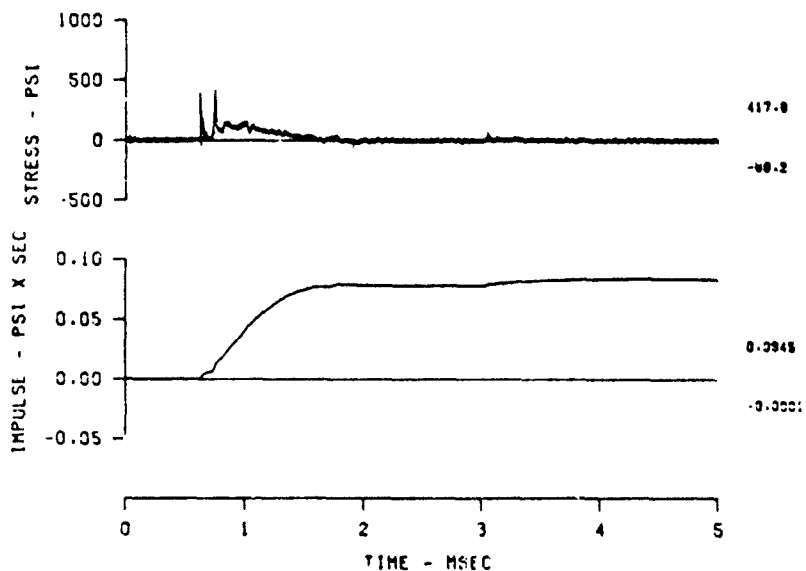
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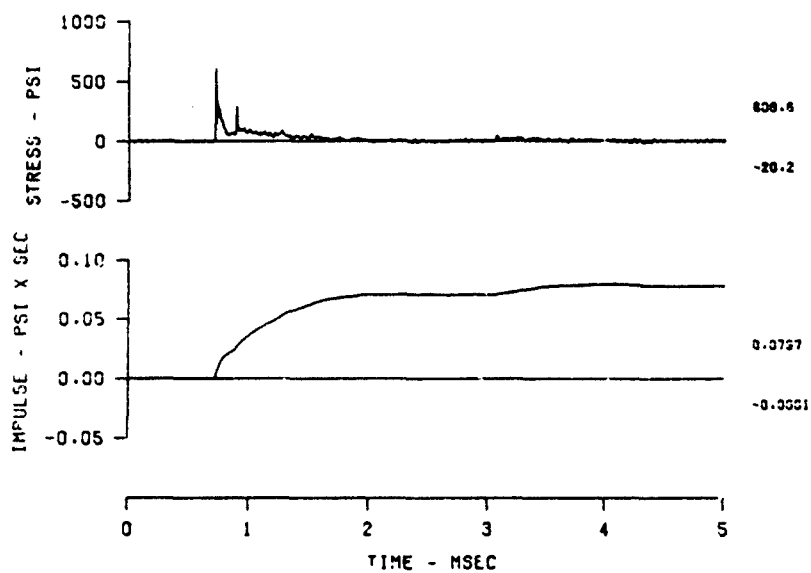
SHOT 10 CH 3 2
 AIRBLAST PENETRATION 1993 LONG SQUARE
 500000.HZ 02/29/84



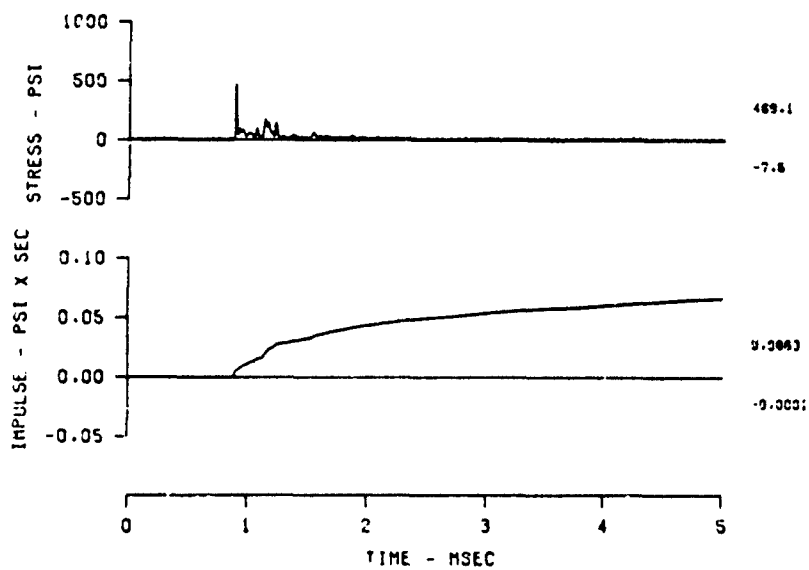
SHOT 10 CH 4 3
 AIRBLAST PENETRATION 1993 LONG SQUARE
 500000.HZ 02/29/84



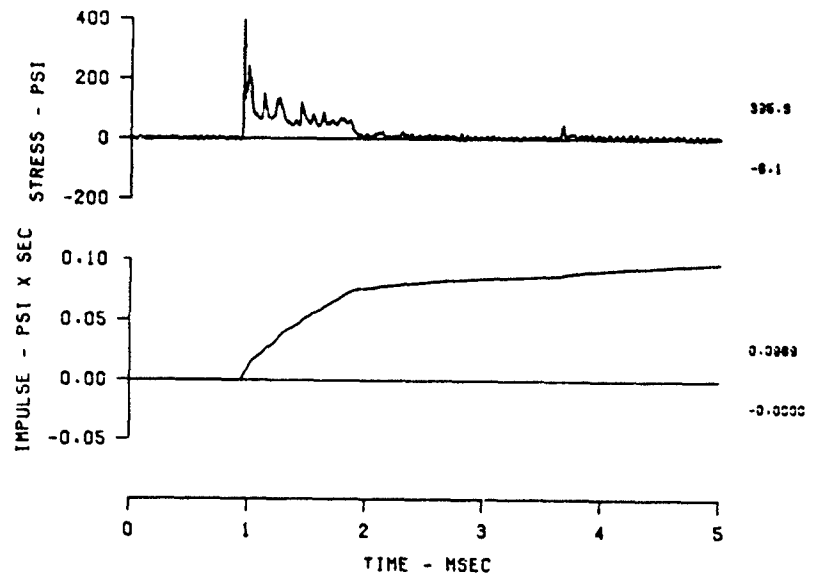
SHOT 10 CH 5 4
AIRBLAST PENETRATION 1993 LONG SQUARE
500000.HZ 02/29/84



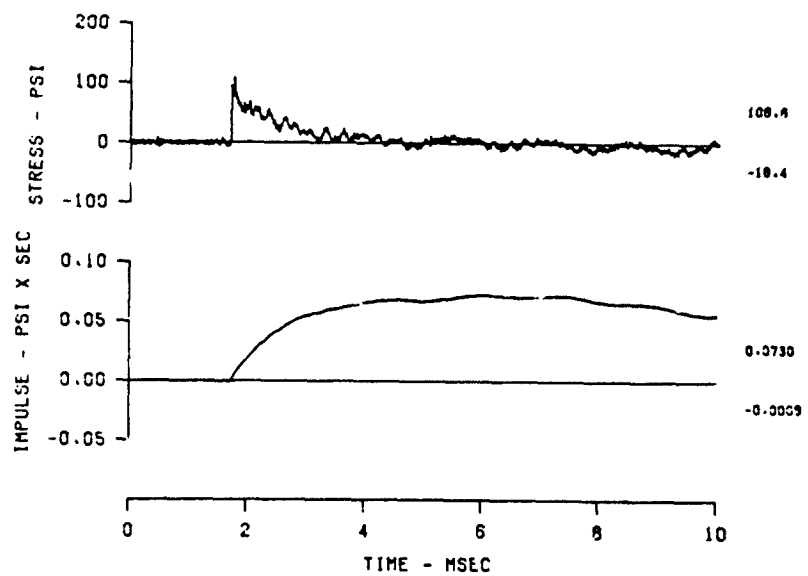
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AIRBLAST PENETRATION 1993 LONG SQUARE
500000.HZ 02/29/84



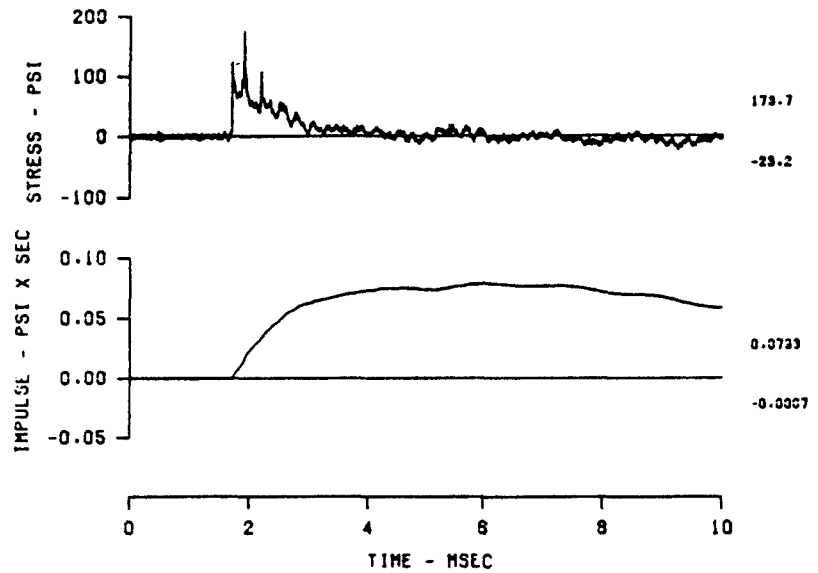
SHOT 10 CH 7 6
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/29/84



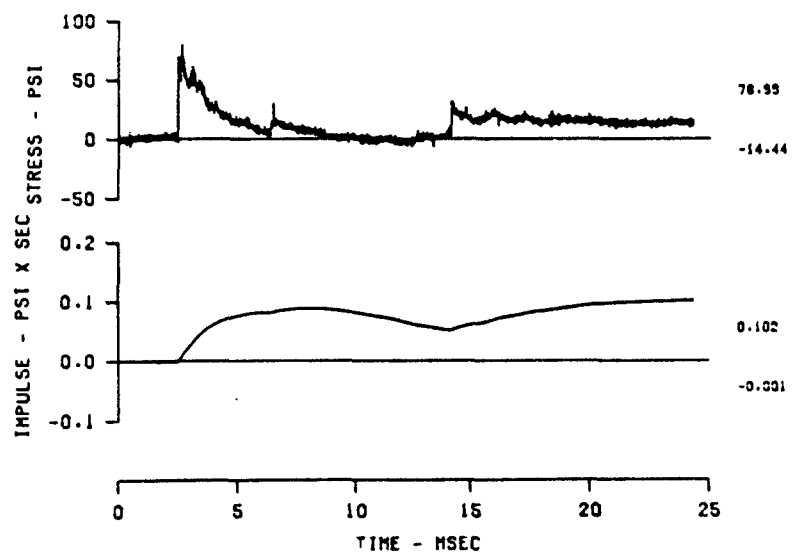
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500000.HZ 02/29/84



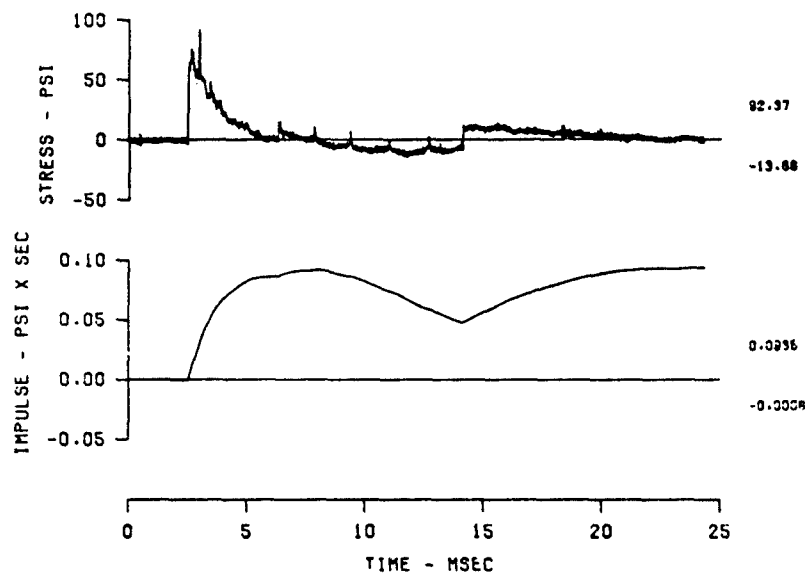
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500000.HZ 02/29/84



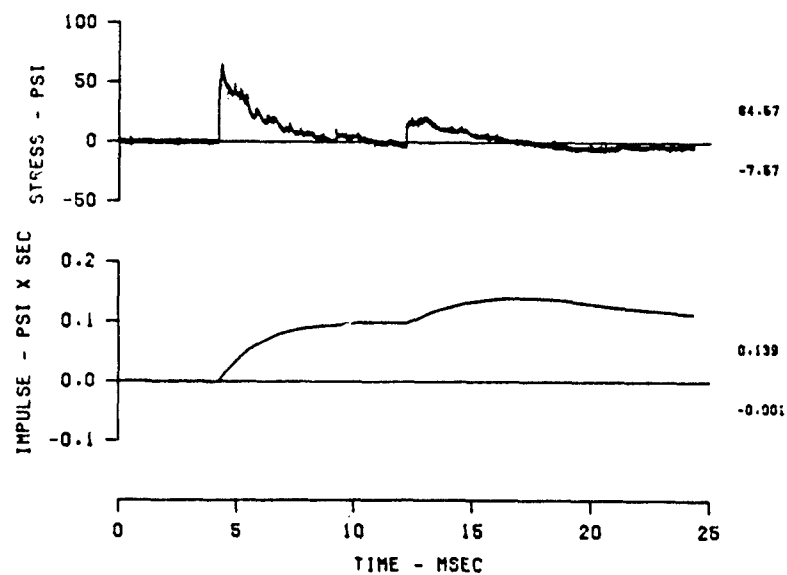
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500000.HZ 02/29/84



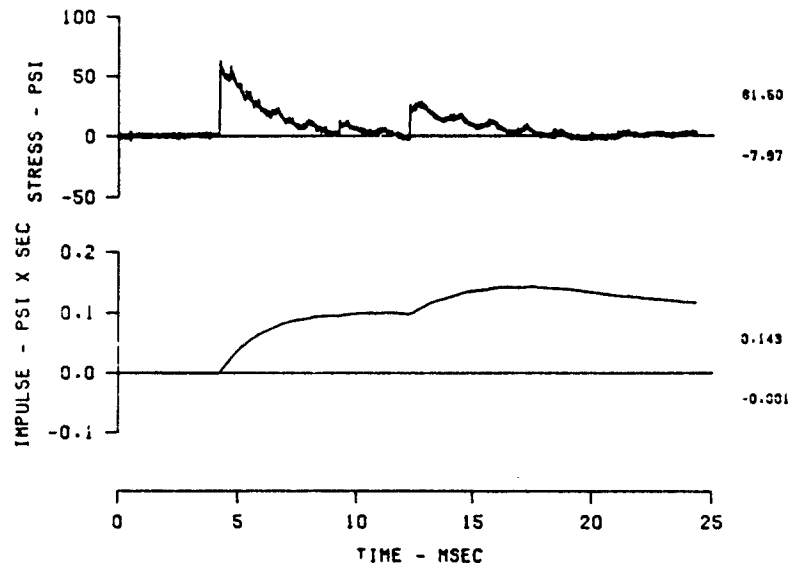
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500000.HZ 02/29/84



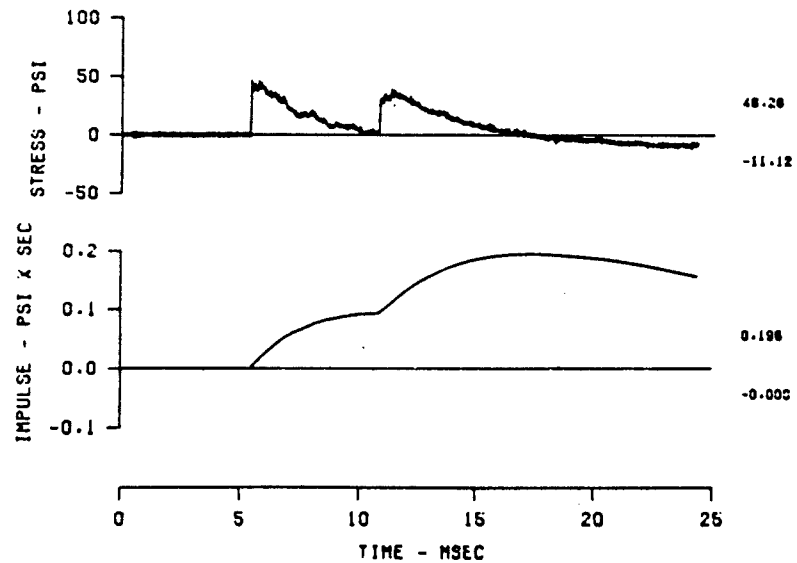
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500000.HZ 02/29/84



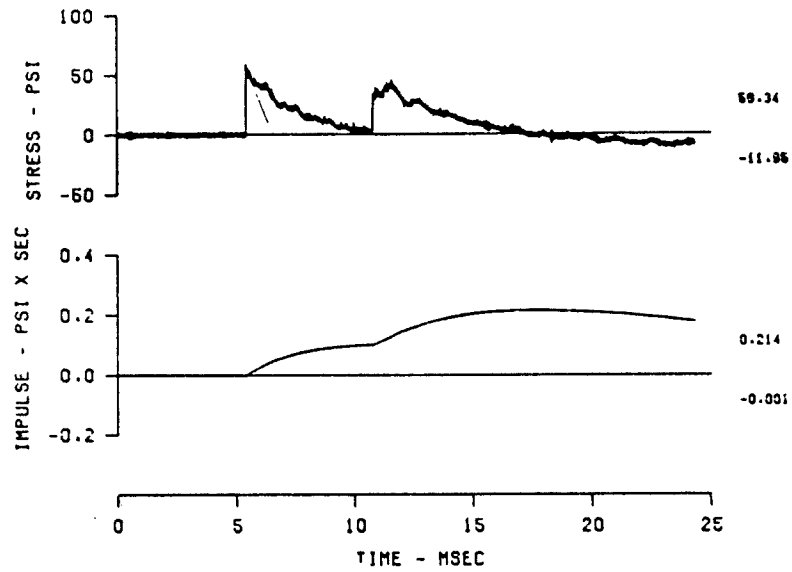
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500000.HZ 02/29/84



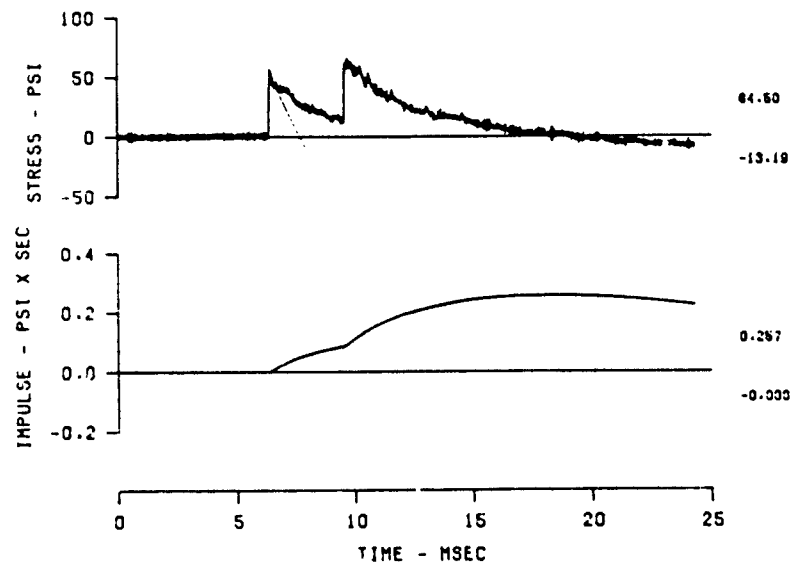
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500000.HZ 02/29/84



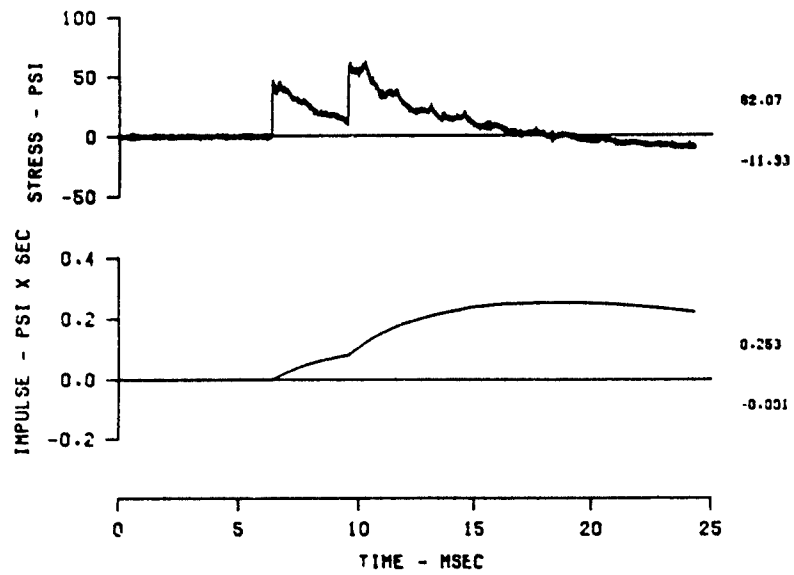
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AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/29/84



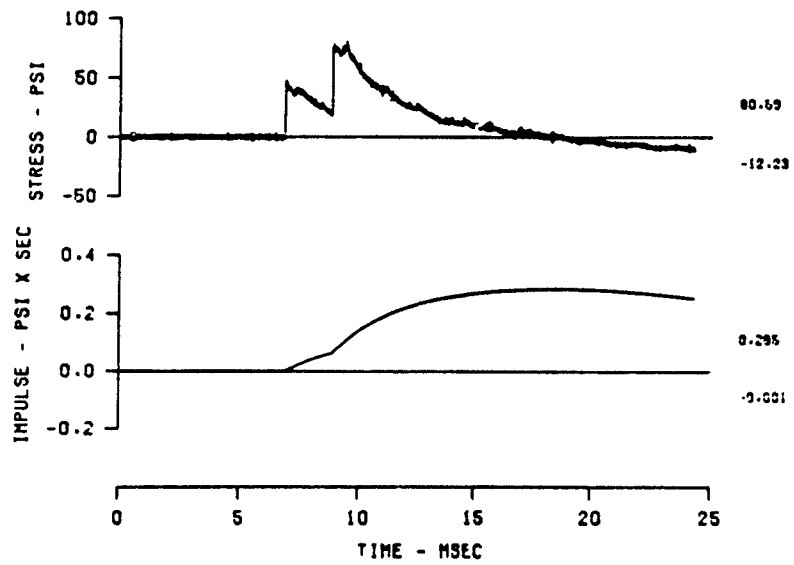
SHOT 10 CH 16 15
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/29/84



SHOT 10 CH 17 16
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/29/84

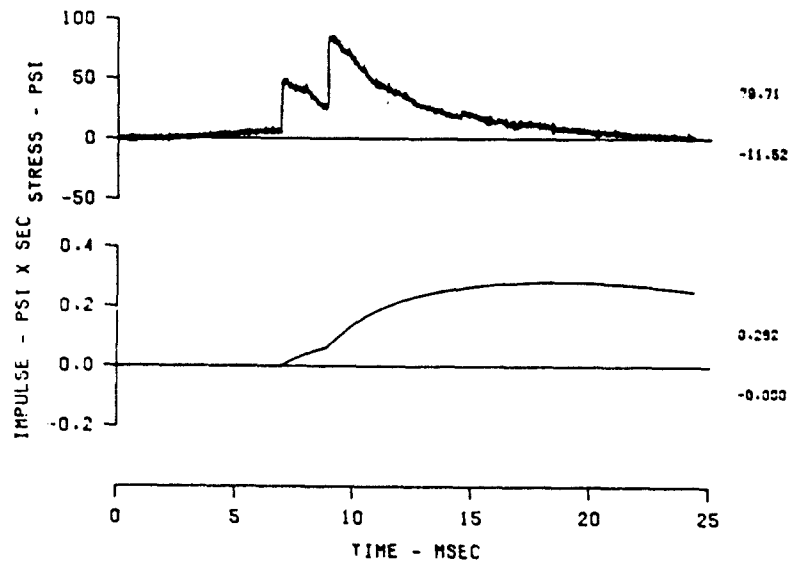


SHOT 10 CH 18 17
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/29/84

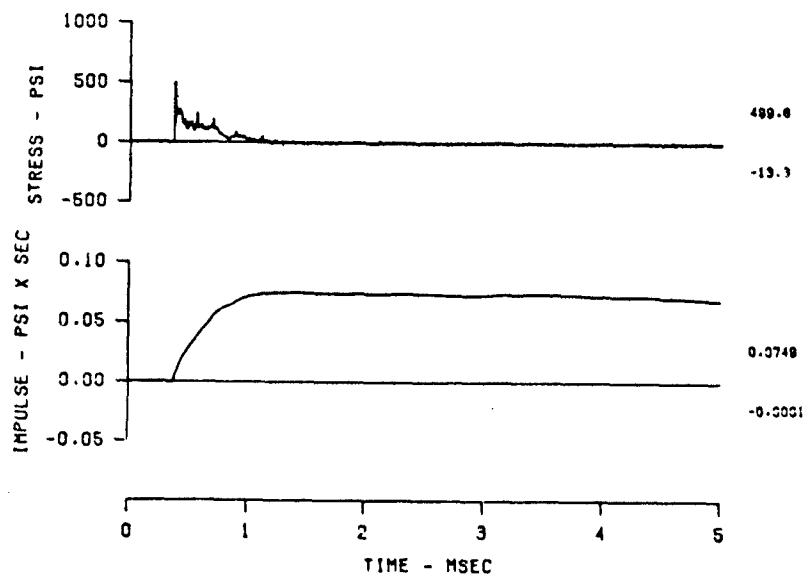


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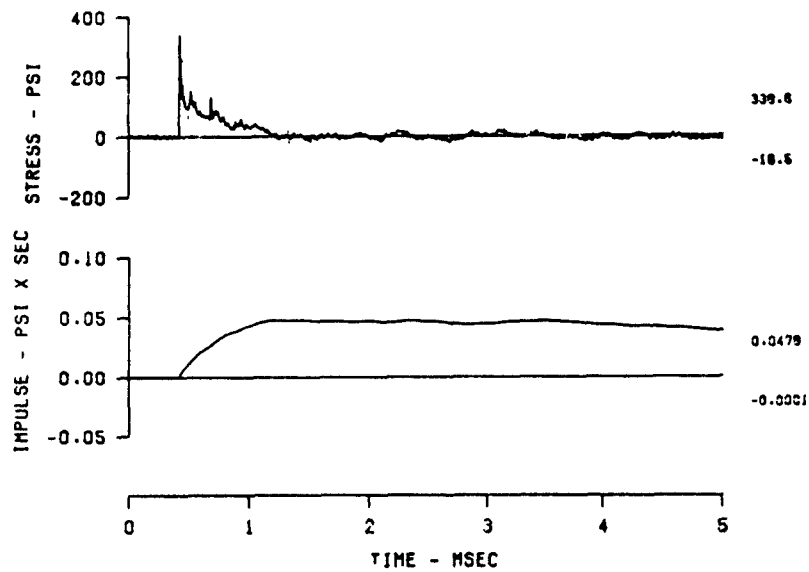
SHOT 10 CH 19 18
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/29/84



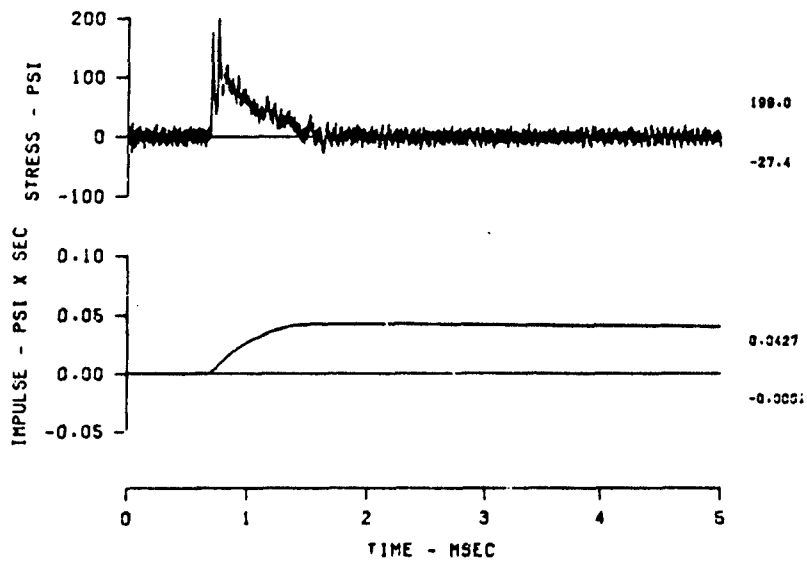
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500000.HZ 02/29/84



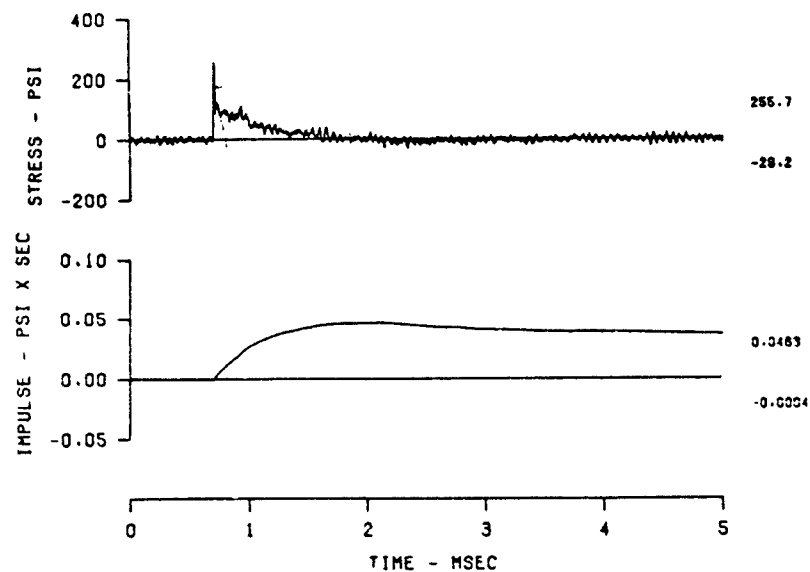
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500000.HZ 02/29/84



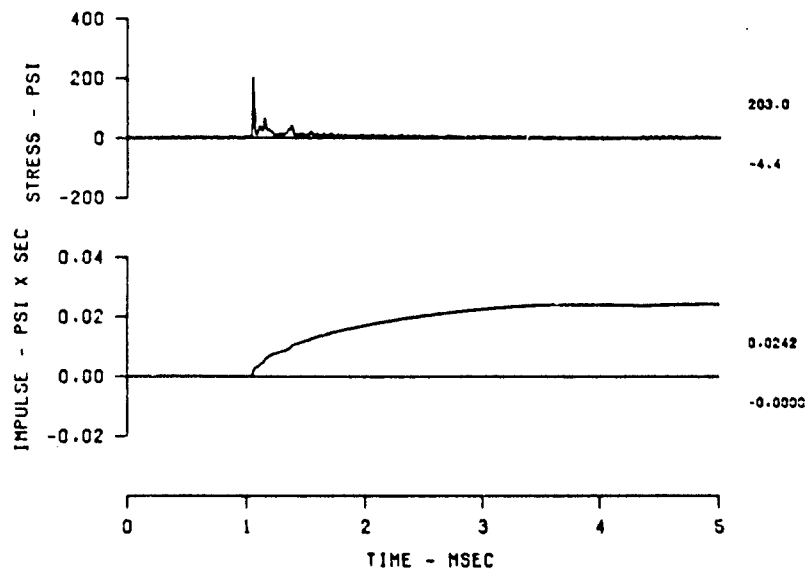
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AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/29/84



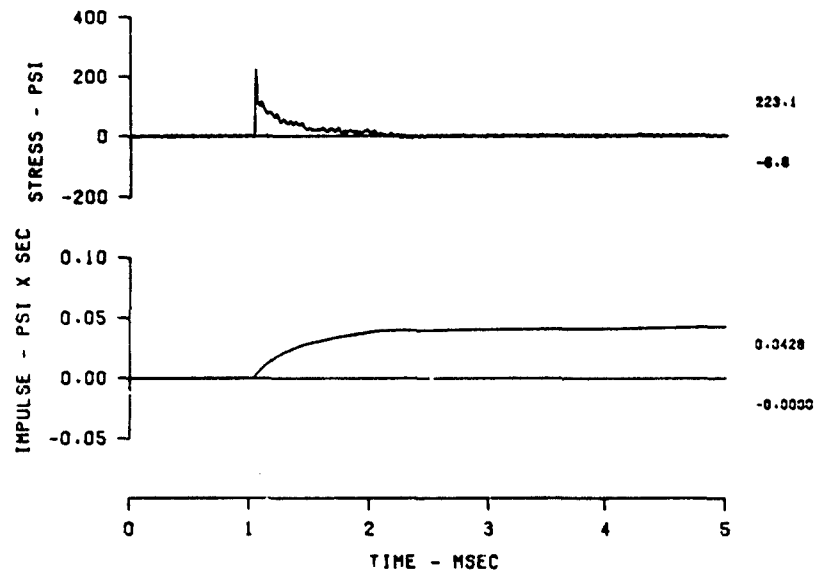
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500000.HZ 02/29/84



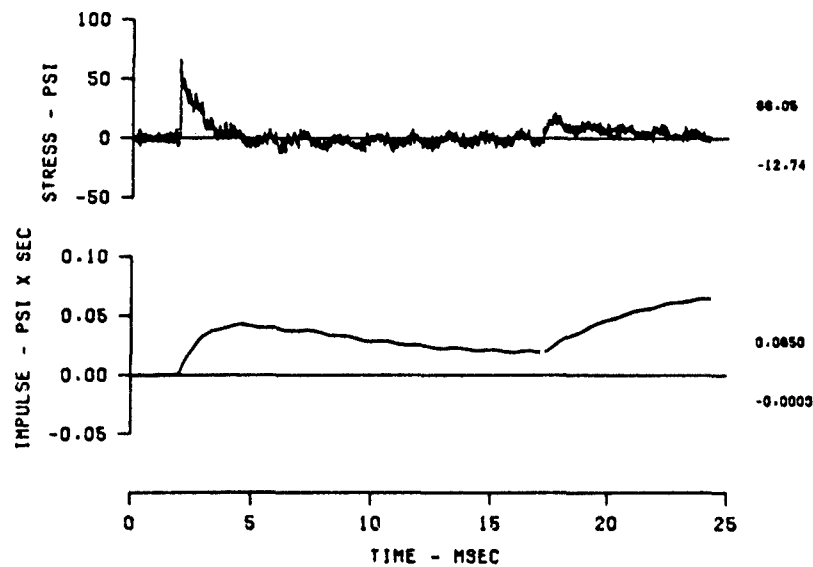
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AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/29/84



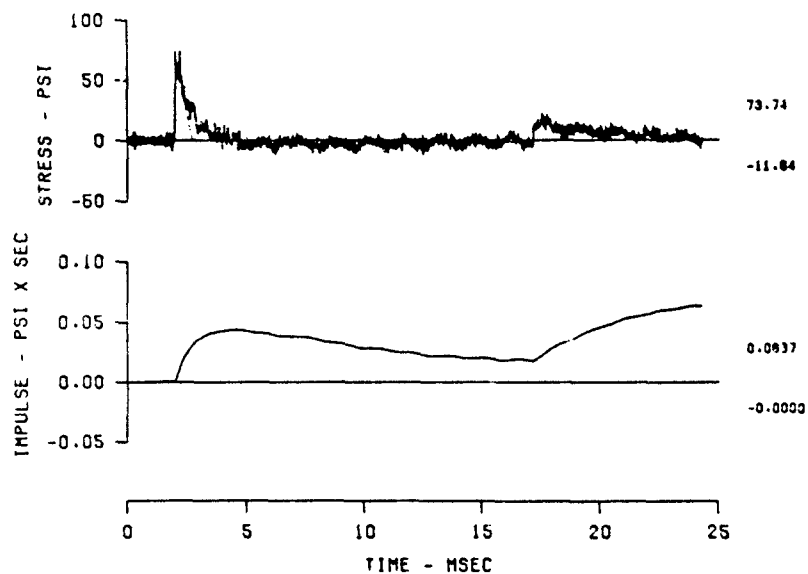
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500000.HZ 02/29/84



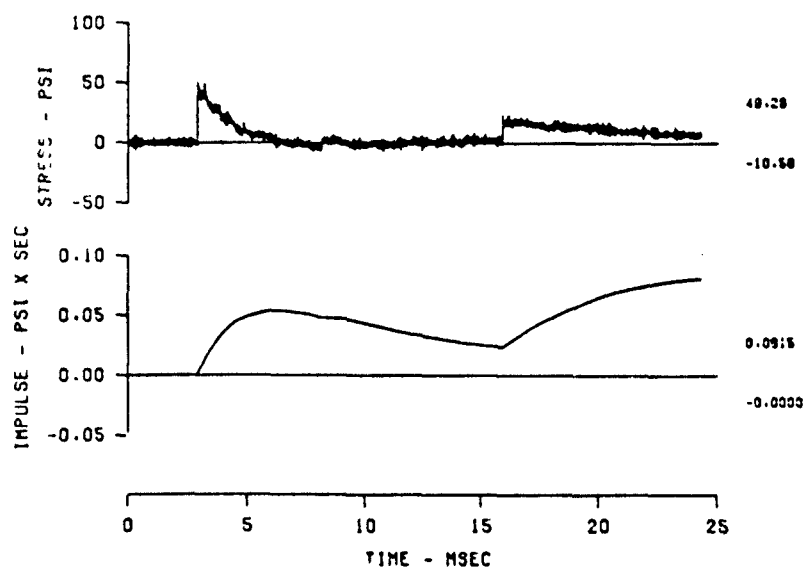
SHOT 11 CH 8 7
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/29/84



SHOT 11 CH 9 8
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/29/84

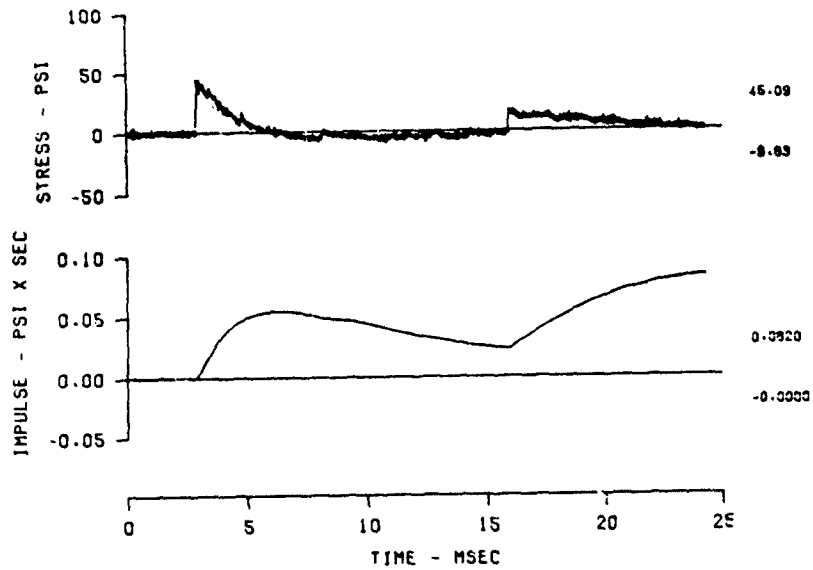


SHOT 11 CH 10 9
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/29/84

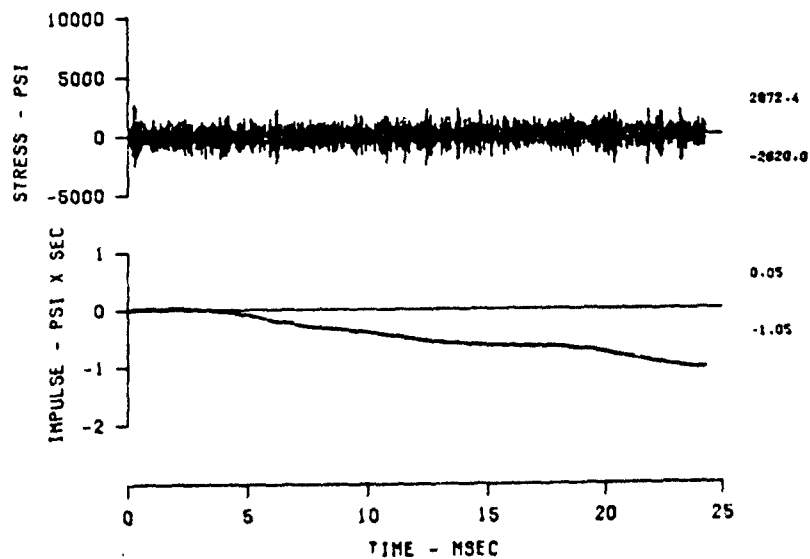


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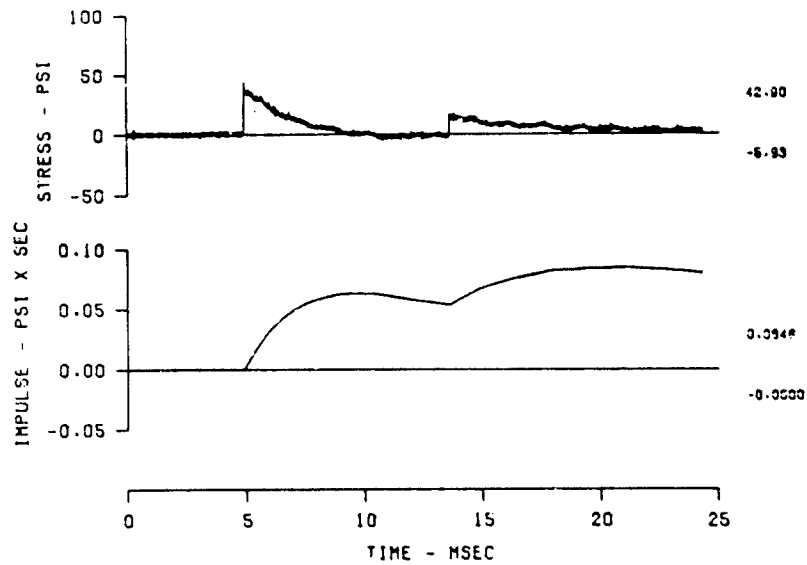
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500000.HZ 02/29/84



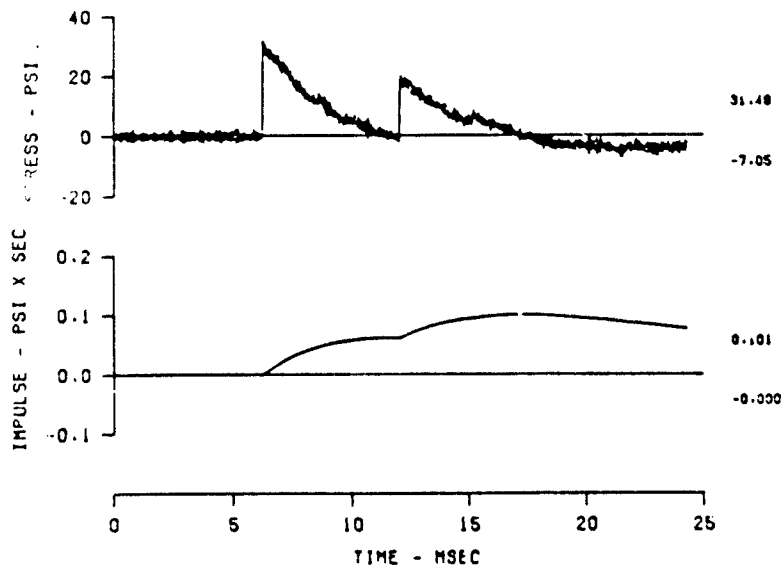
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500000.HZ 02/29/84



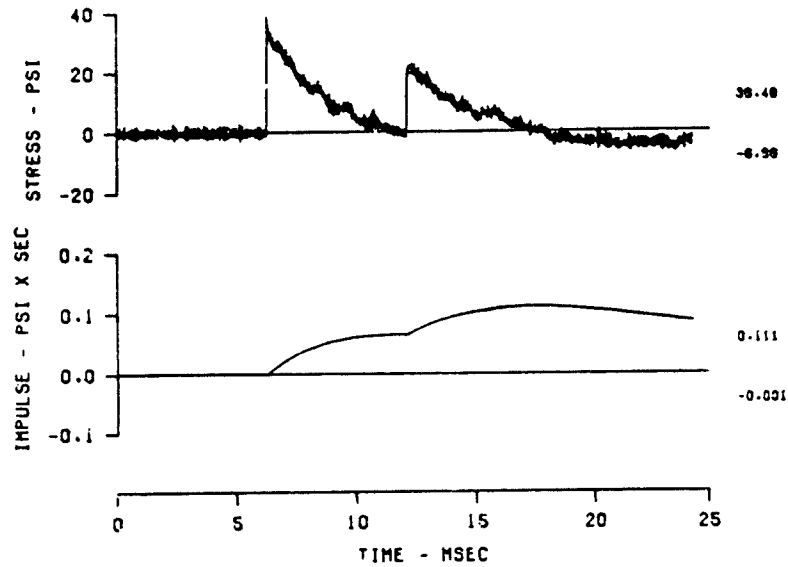
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 500000.HZ 02/29/84



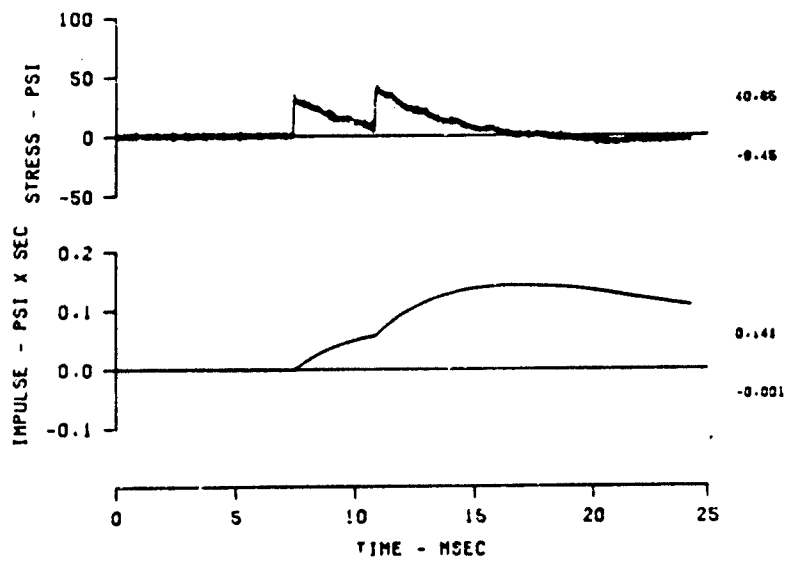
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 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/29/84



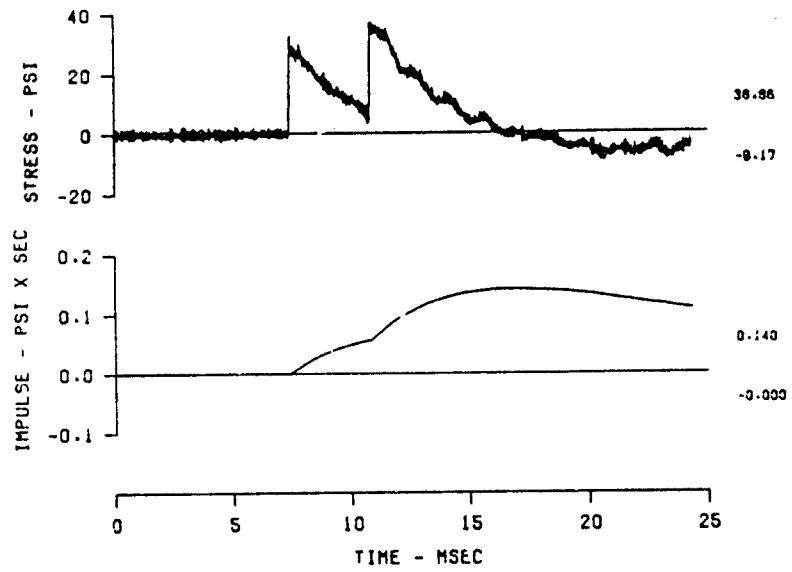
SHOT 11 CH 15 14
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/29/84



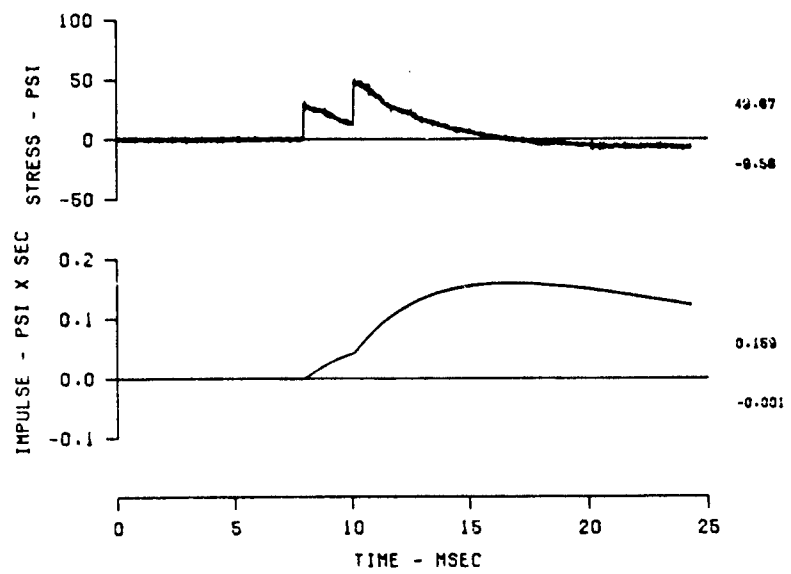
SHOT 11 CH 16 15
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/29/84



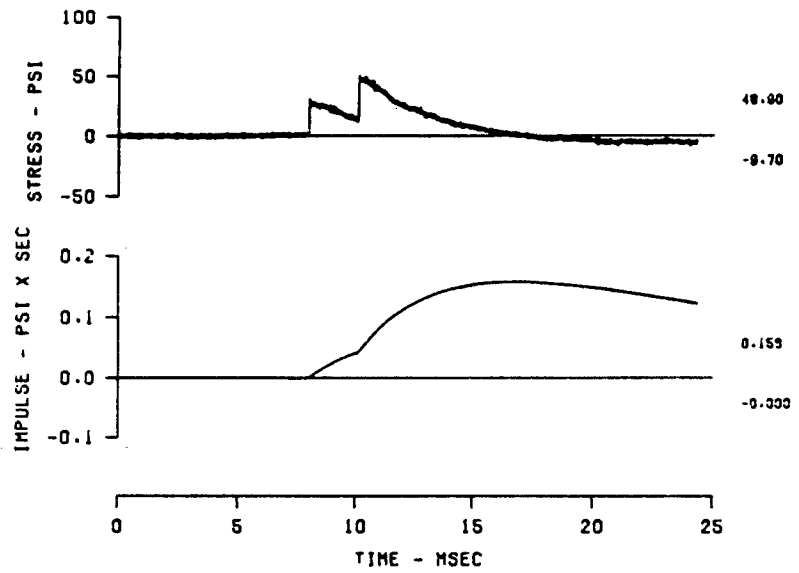
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500000.HZ 02/29/84



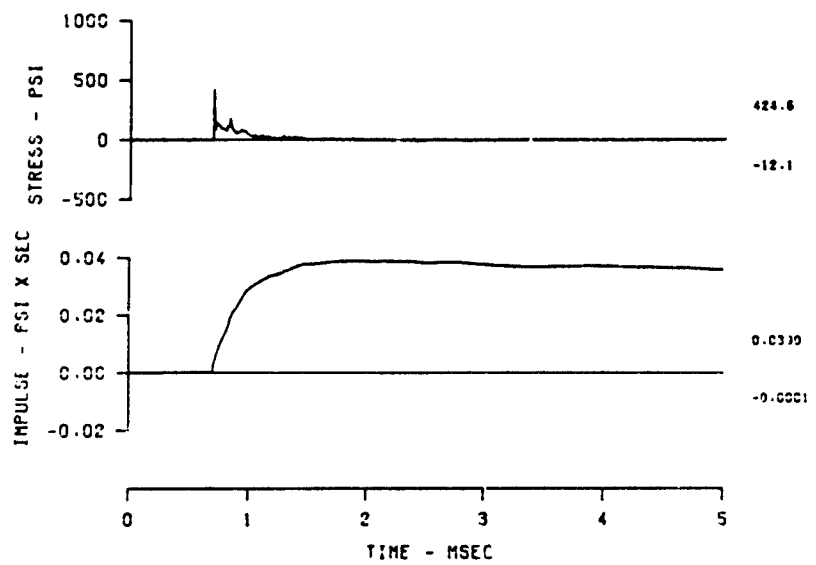
SHOT 11 CH 18 17
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/29/84



SHOT 11 CH 19 18
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/29/84

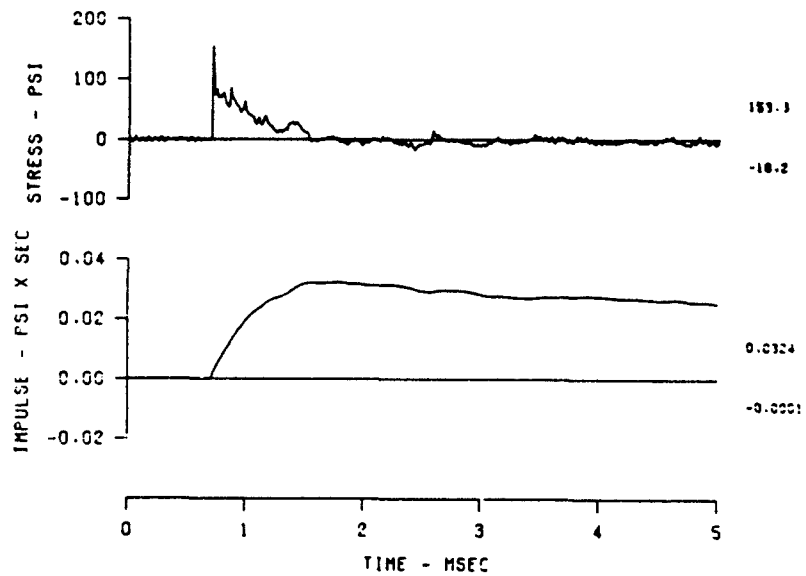


SHOT 13 CH 2 1
AIRBLAST PENETRATION 1983 LONG SQUARE
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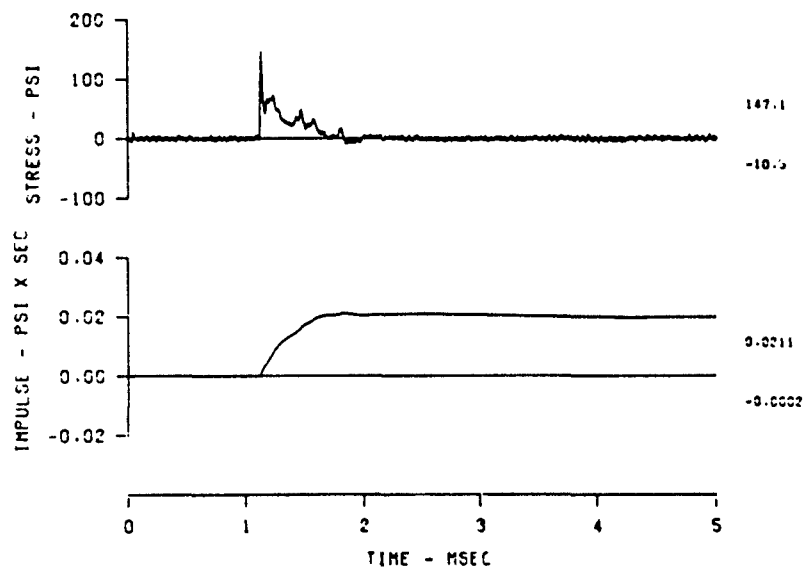


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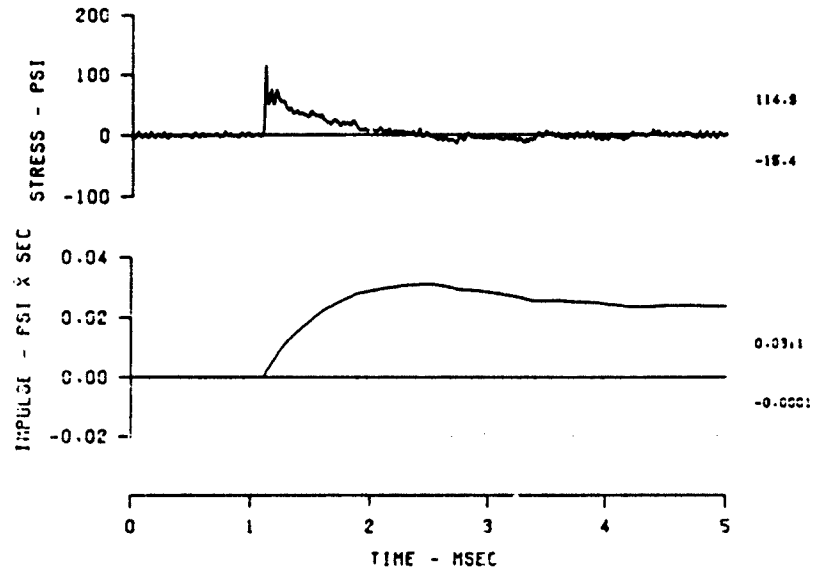
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500000.HZ 02/27/84



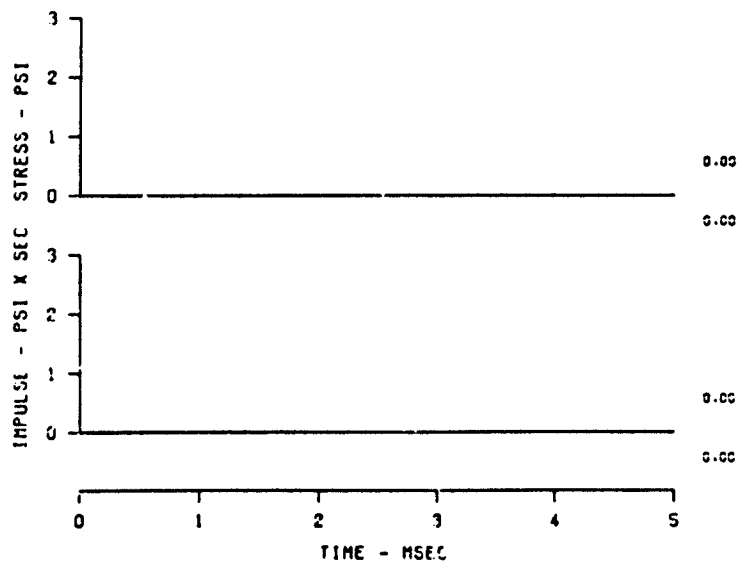
SHOT 13 CH 4 3
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84



SHOT 13 CH 5 4
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/27/84

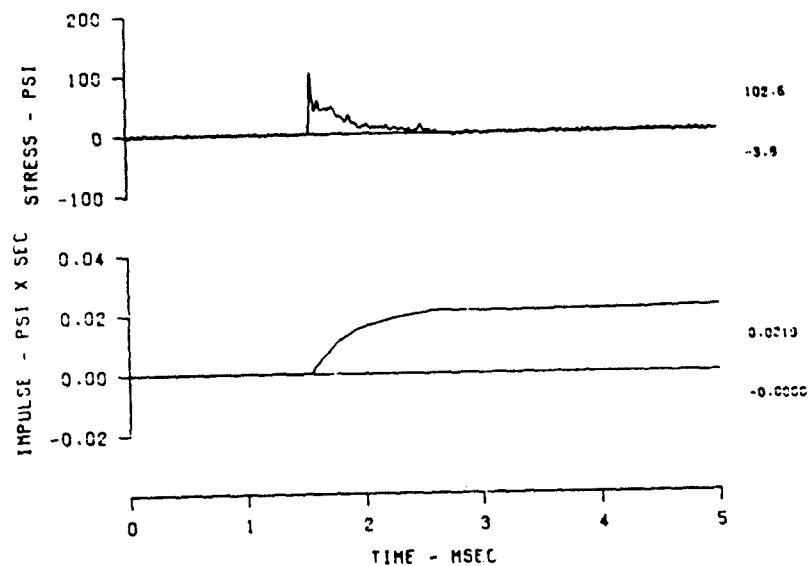


SHOT 13 CH 6 5
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/27/84

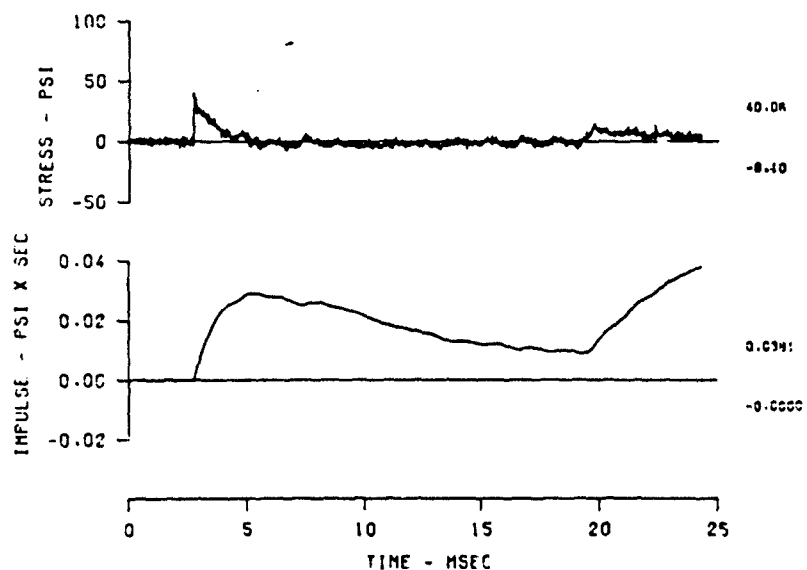


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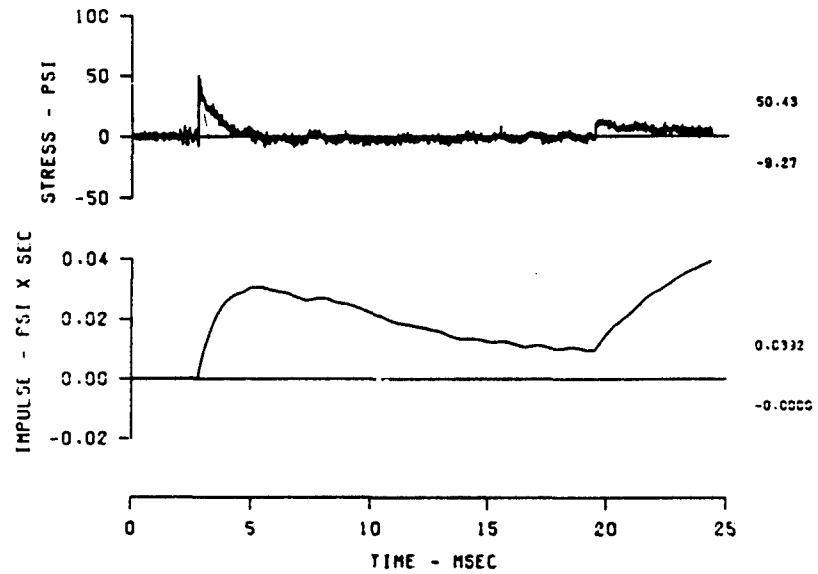
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AIRBLAST PENETRATION 1983 LONG SQUARE
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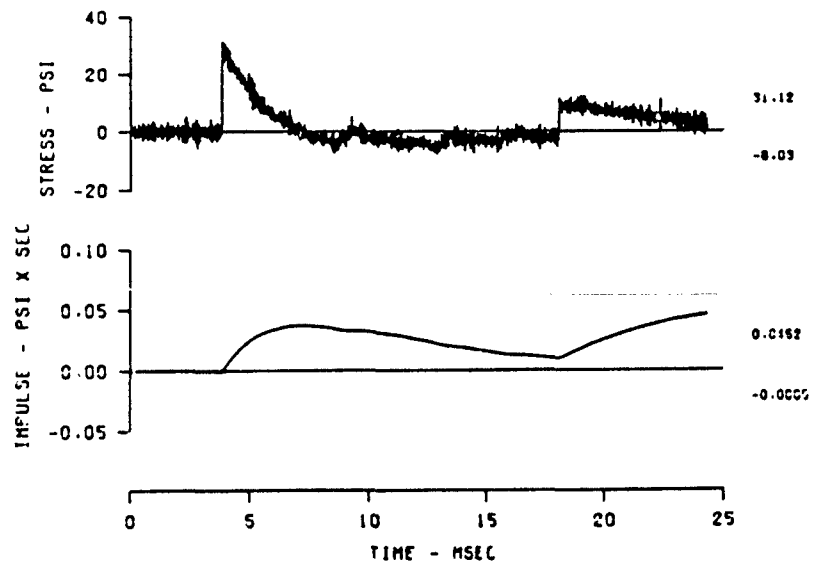
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500000.HZ 02/27/84



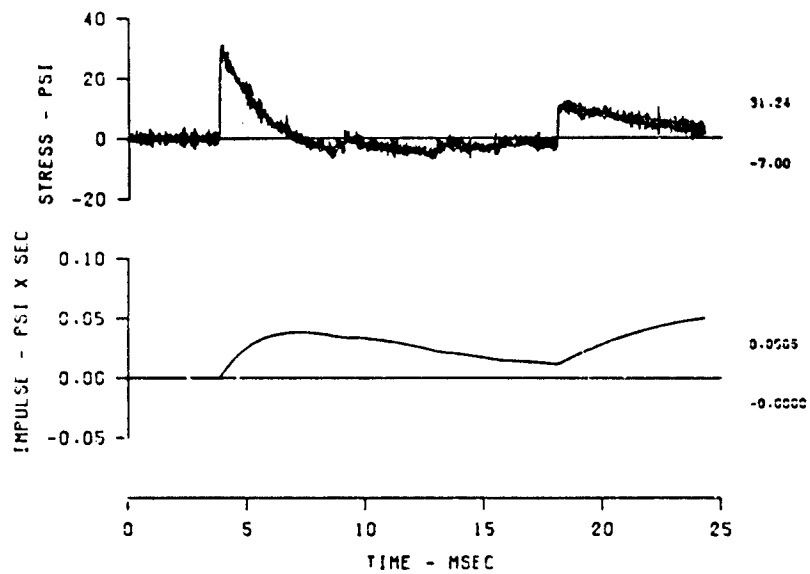
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AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84



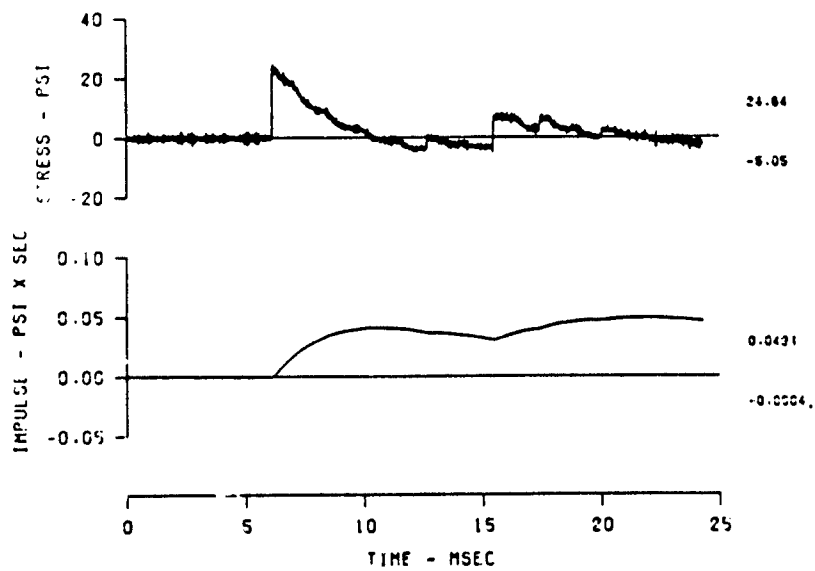
SHOT 13 CH 10 9
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84



SHOT 13 CH 11 10
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84

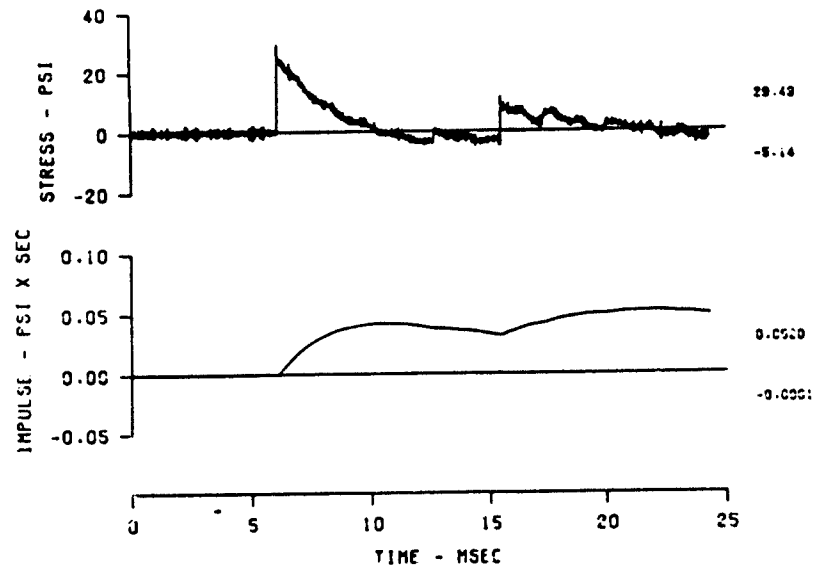


SHOT 13 CH 12 11
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84

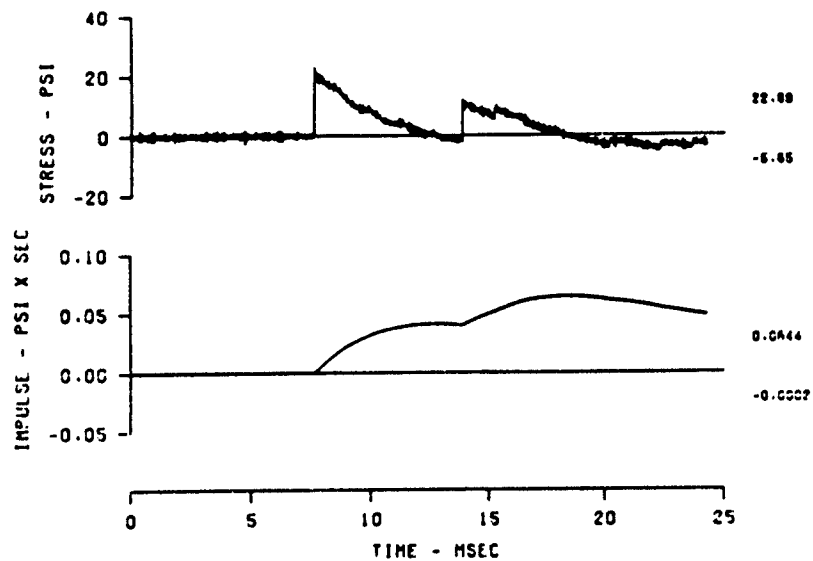


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SHOT 13 CH 13 12
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/27/84

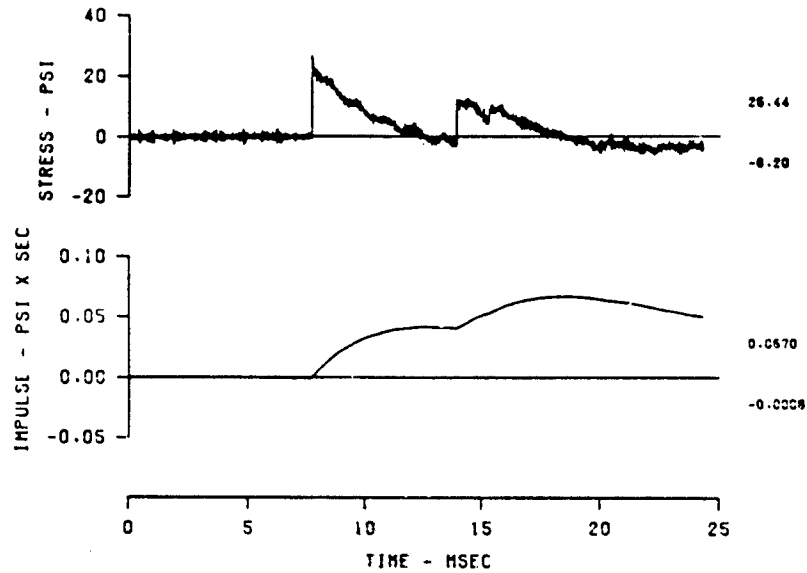


SHOT 13 CH 14 13
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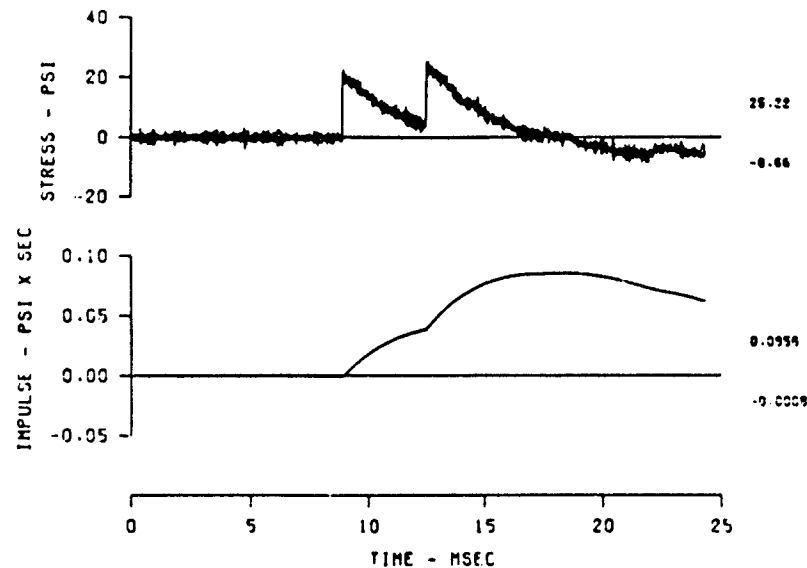


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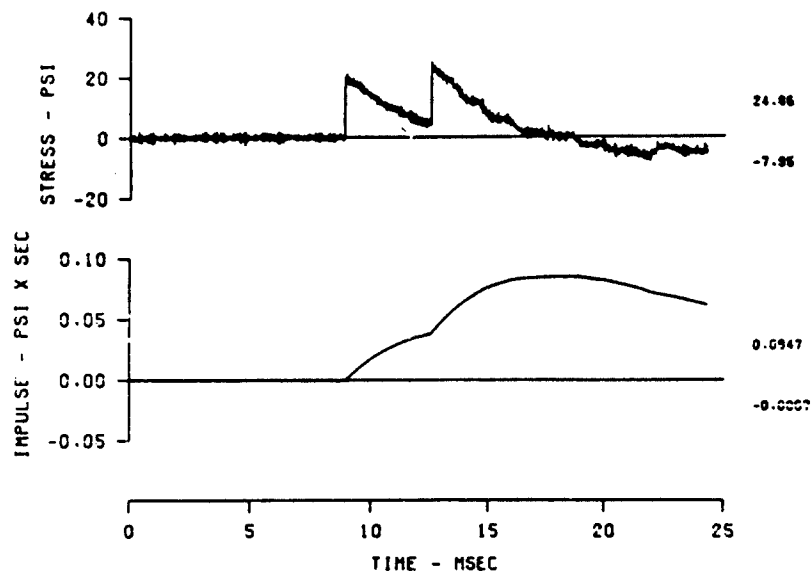
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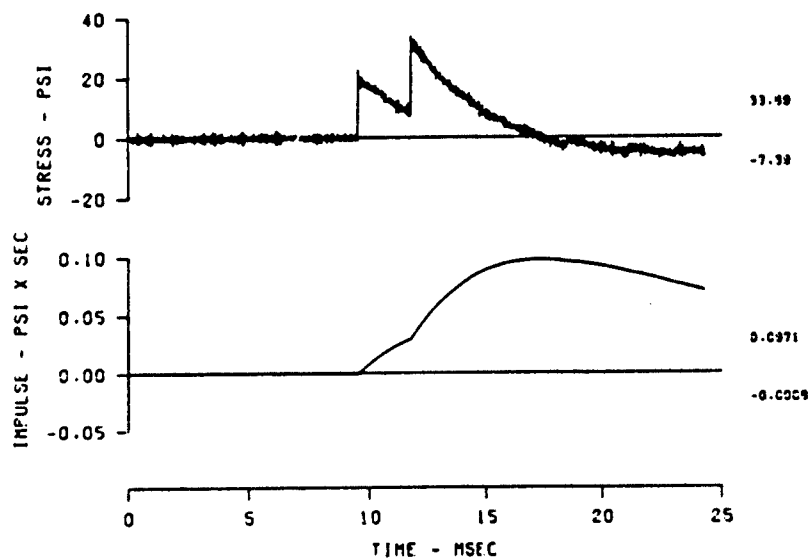
SHOT 13 CH 16 15
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/27/84



SHOT 13 CH 17 16
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/27/84

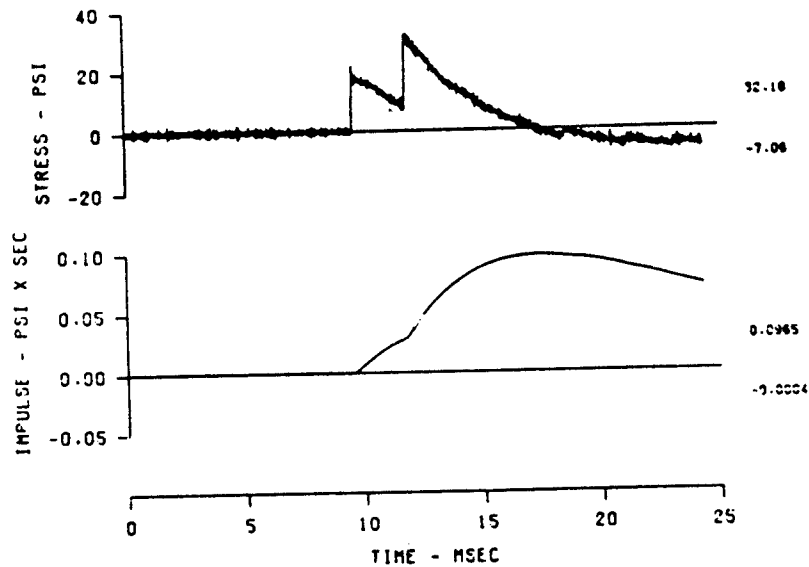


SHOT 13 CH 18 17
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/27/84

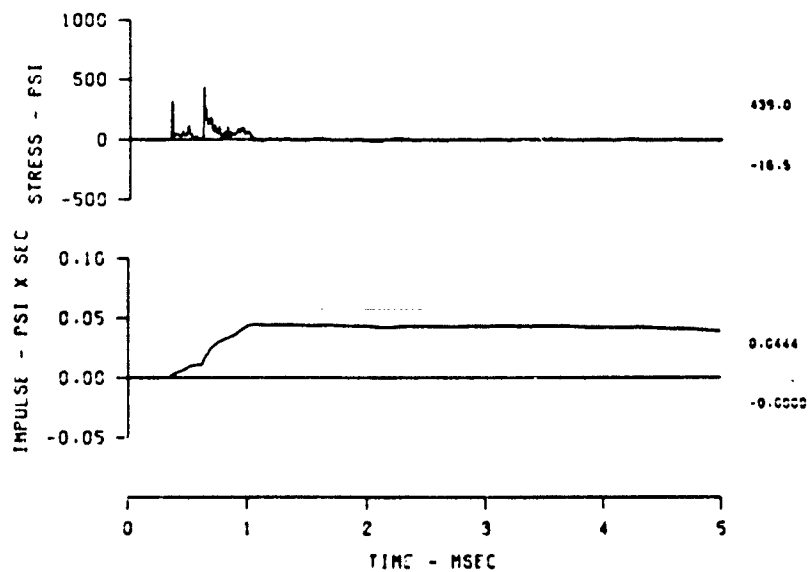


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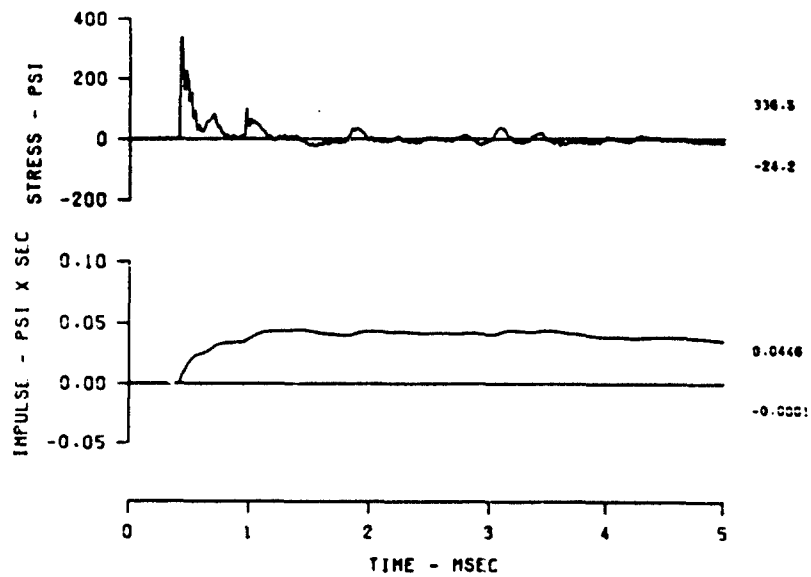
SHOT 13 CH 10 18
 AIRBLAST PENETRATION 1983 LONG SQUARE
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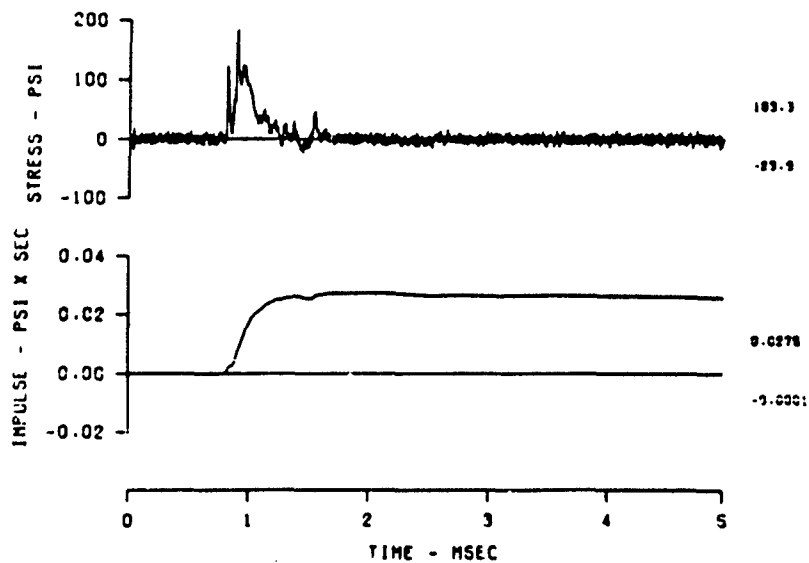
SHOT 14 CH 2 1
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/27/84



SHOT 14 CH 3 2
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84

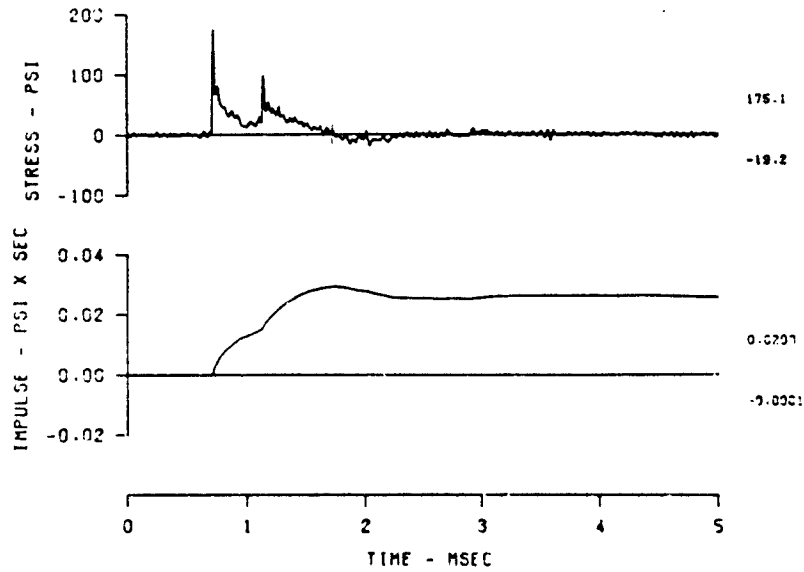


SHOT 14 CH 4 3
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500000.HZ 02/27/84

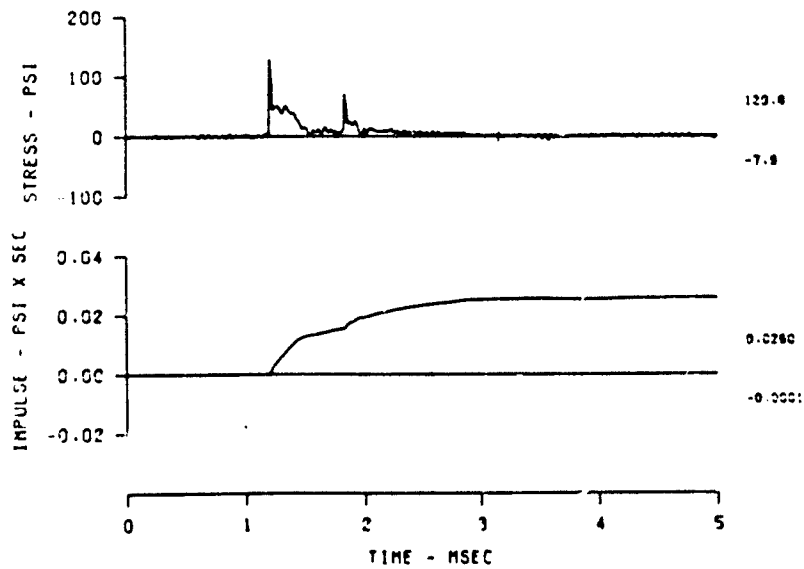


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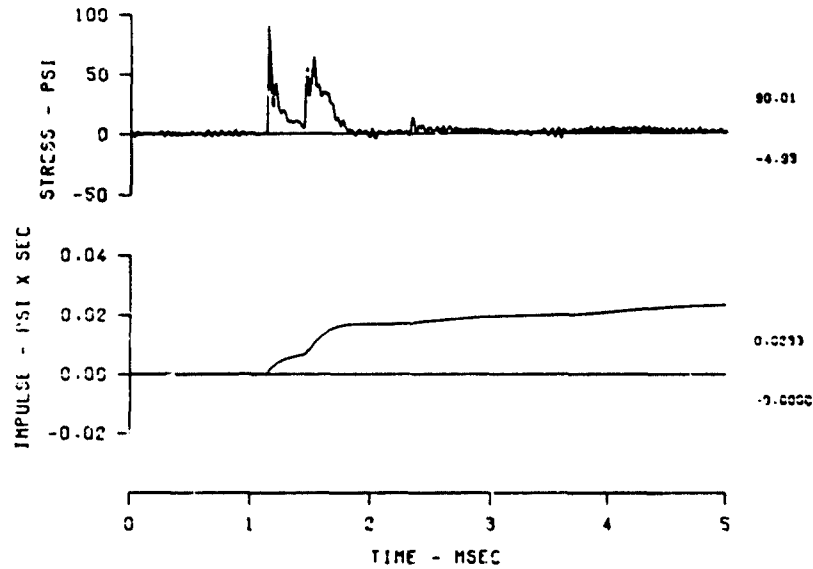
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500000.HZ 02/27/84



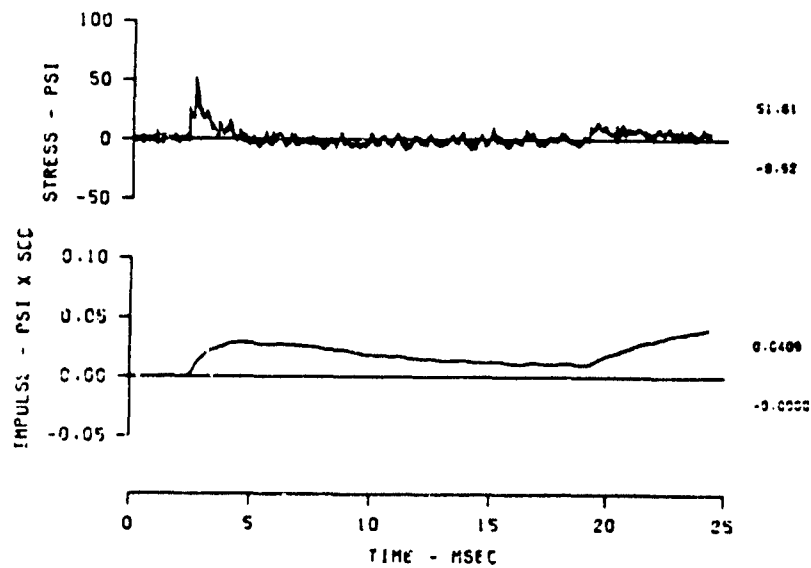
SHOT 14 CH 6 5
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84



SHOT 14 CH 7 6
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84

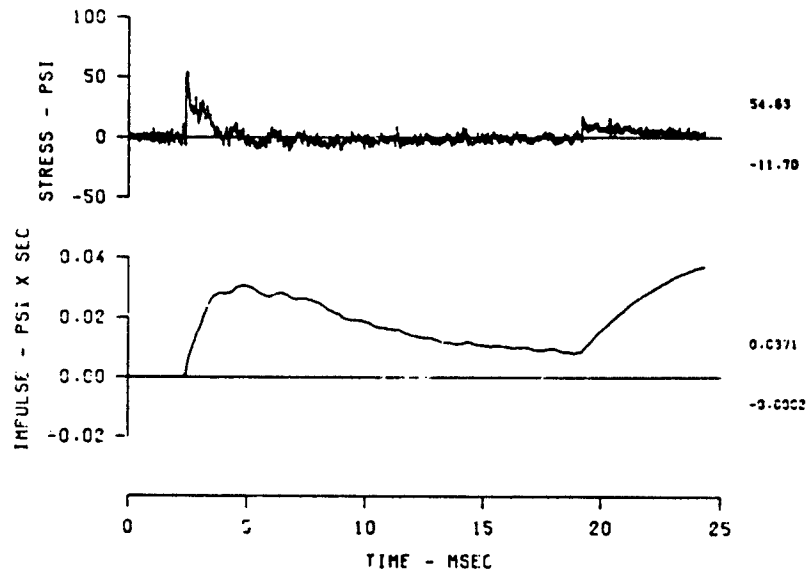


SHOT 14 CH 8 7
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84

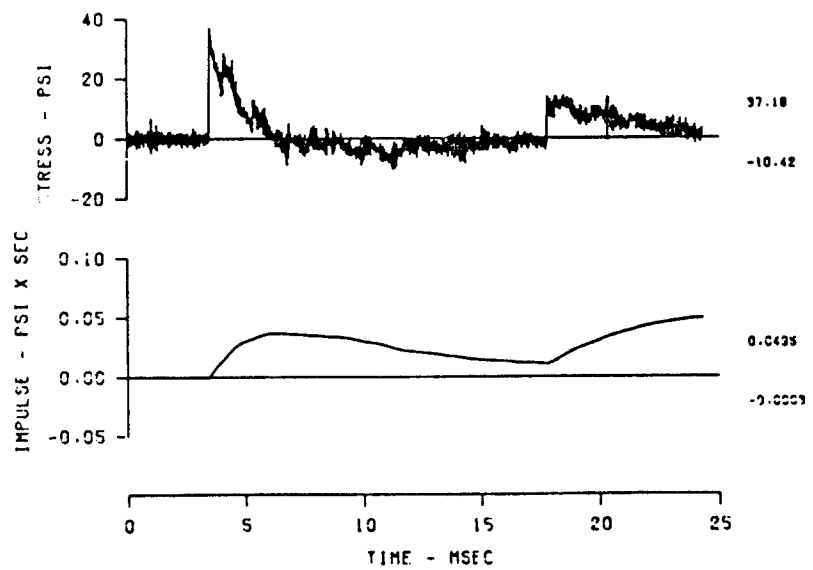


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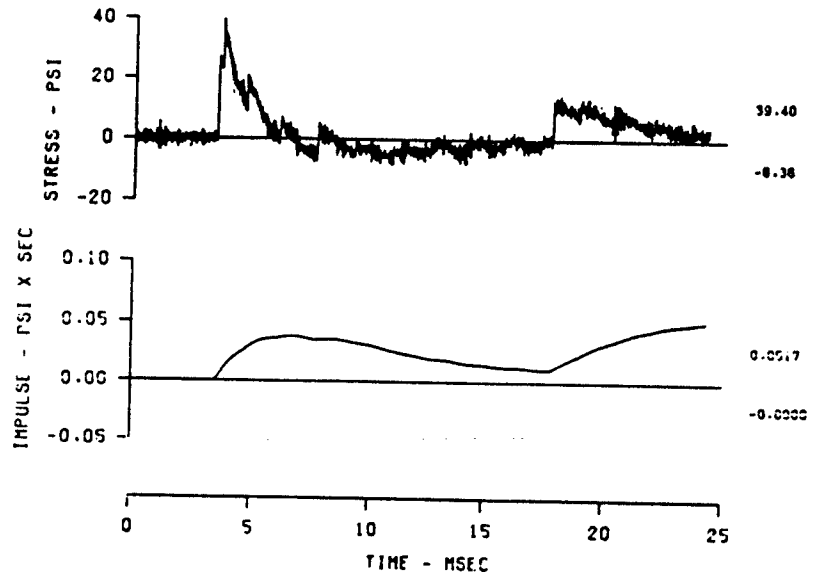
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500000.HZ 02/27/84



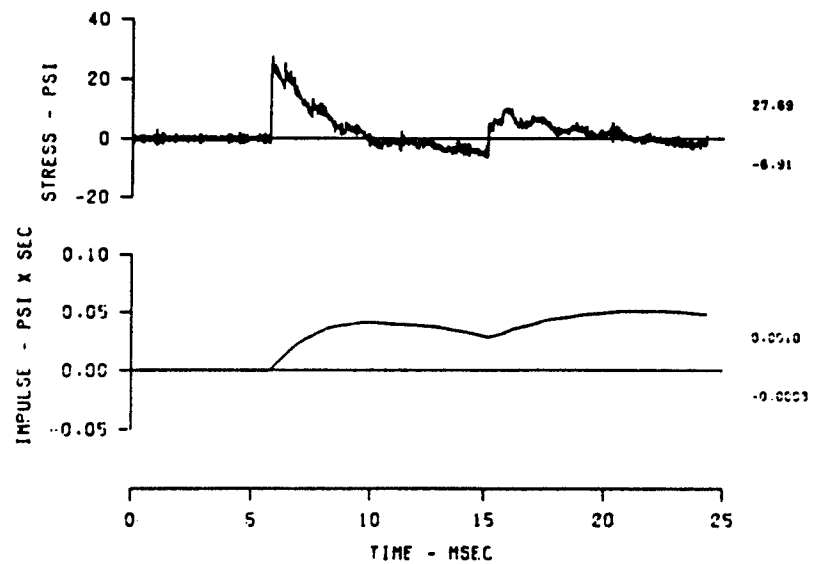
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500000.HZ 02/27/84



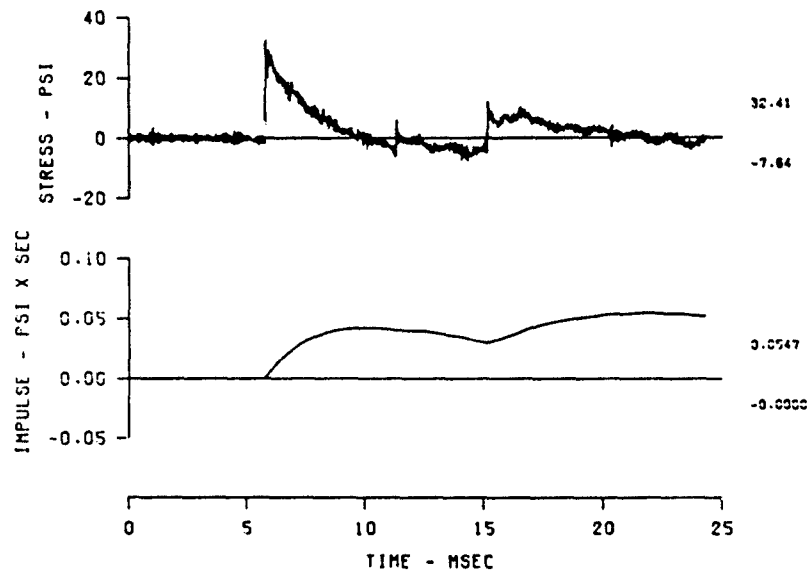
SHOT 14 CH 11 10
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/27/84



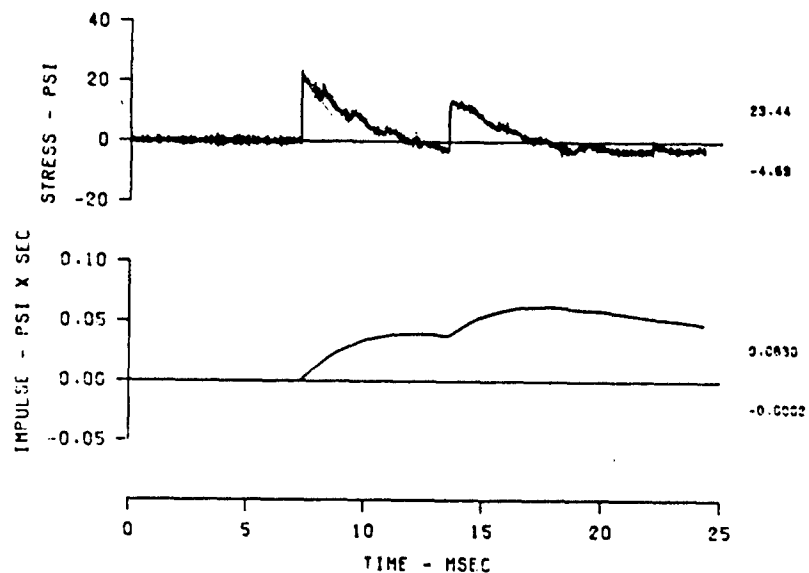
SHOT 14 CH 12 11
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/27/84



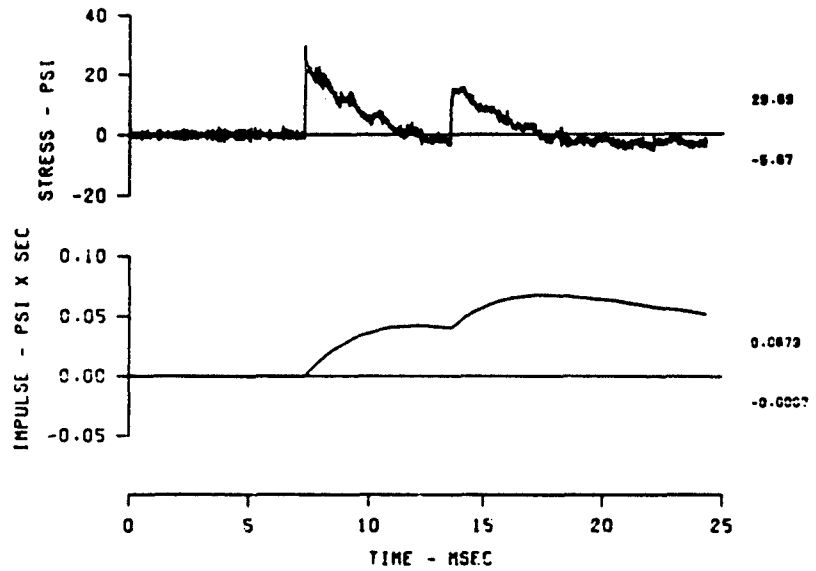
SHOT 14 CH 13 12
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84



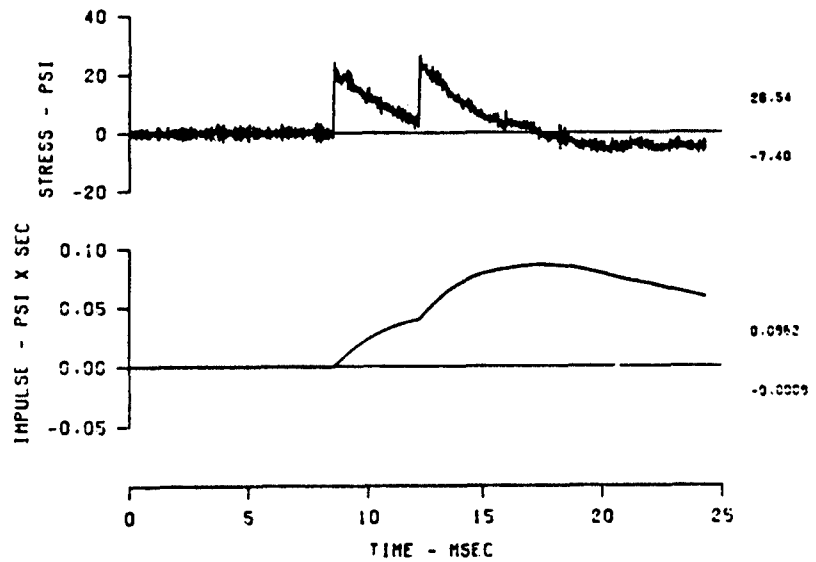
SHOT 14 CH 14 13
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500000.HZ 02/27/84



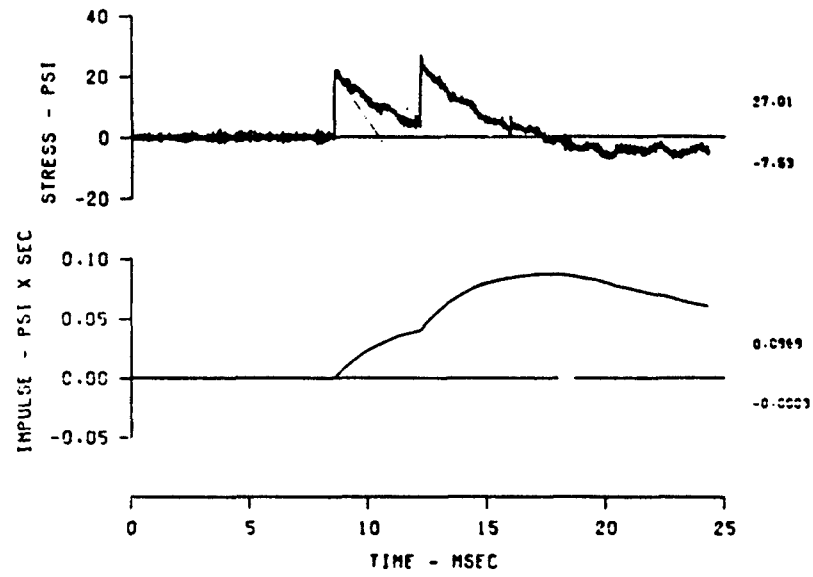
SHOT 14 CH 15 14
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 500000.HZ 02/27/84



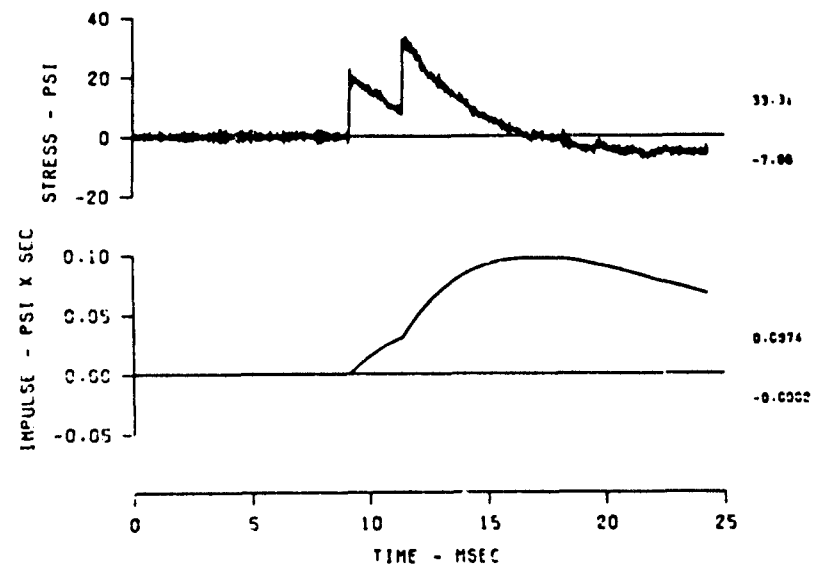
SHOT 14 CH 16 15
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 500000.HZ 02/27/84



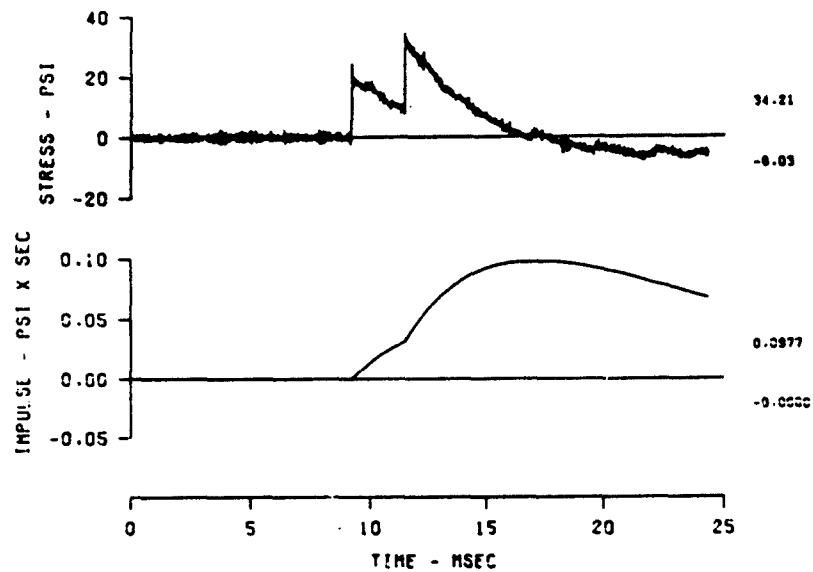
SHOT 14 CH 17 16
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/27/84



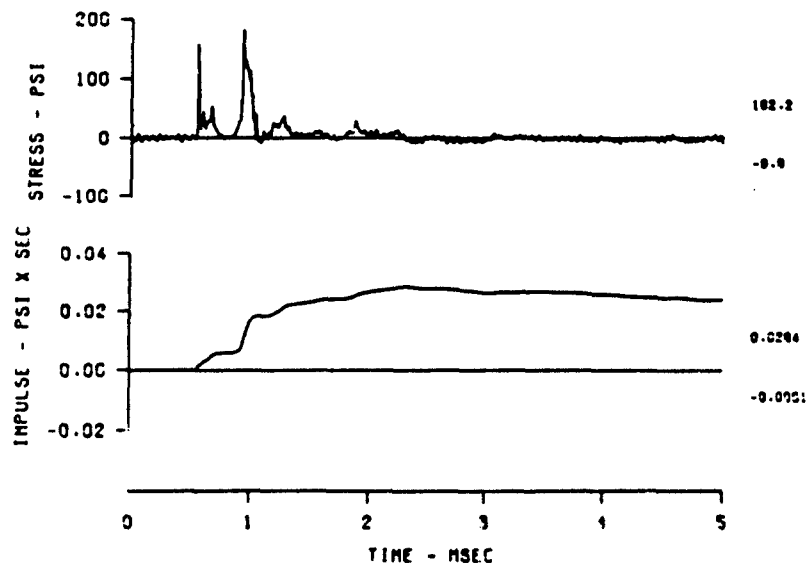
SHOT 14 CH 18 17
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/27/84



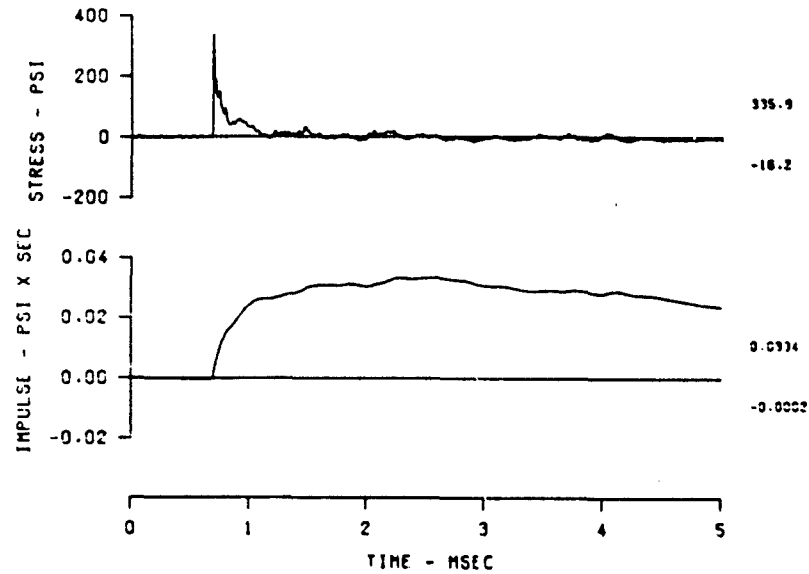
SHOT 14 CH 19 18
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/27/84



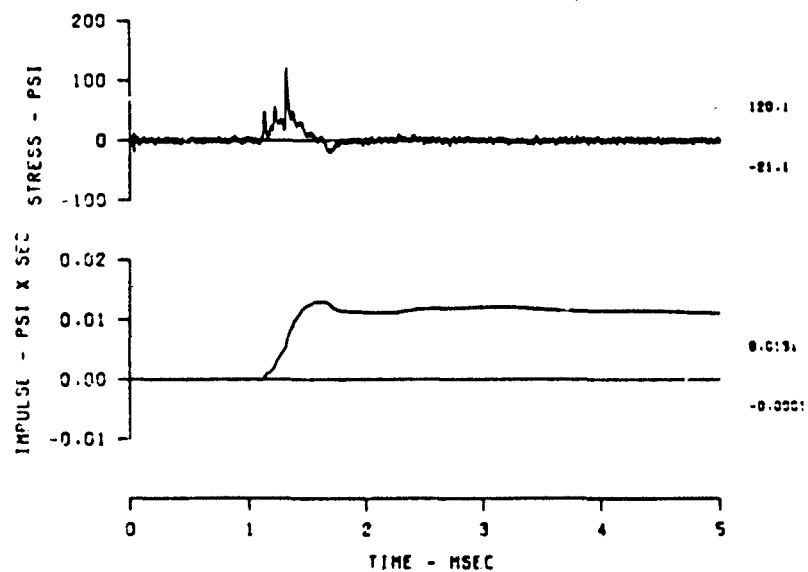
SHOT 15 CH 2 1
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/27/84



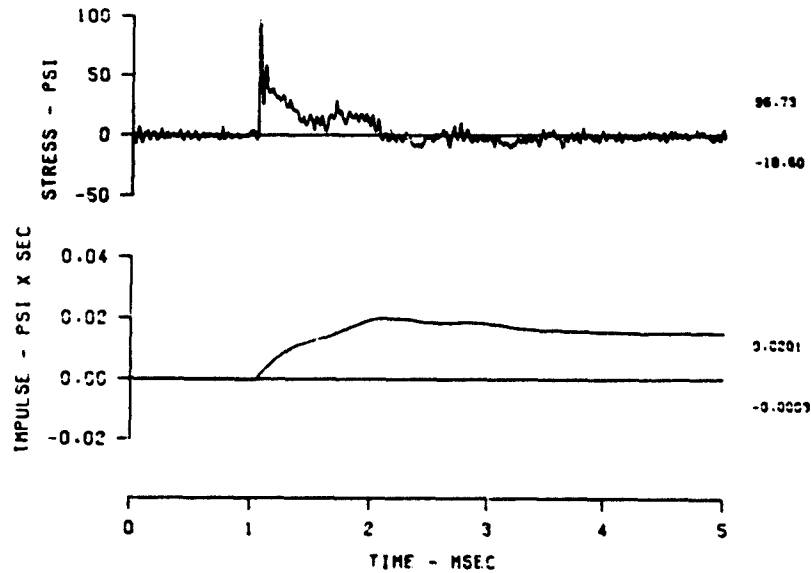
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AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84



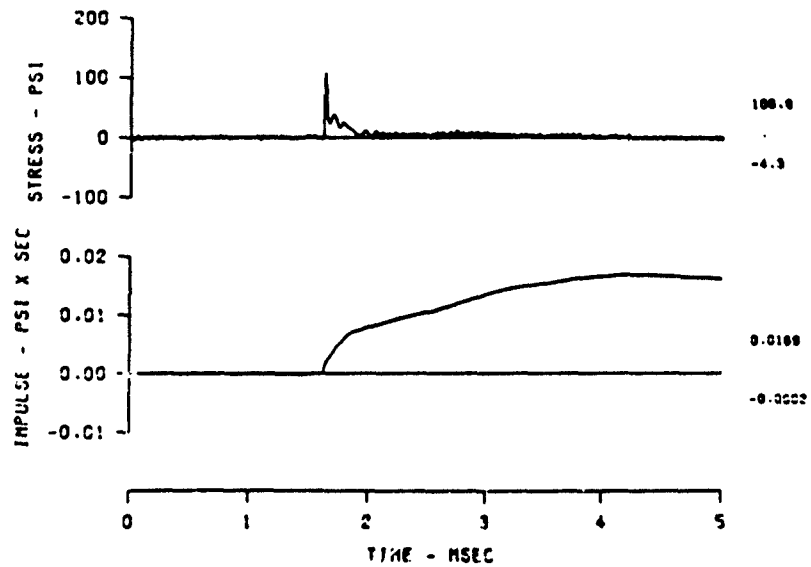
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AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84



SHOT 15 CH 5 4
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500000.HZ 02/27/84

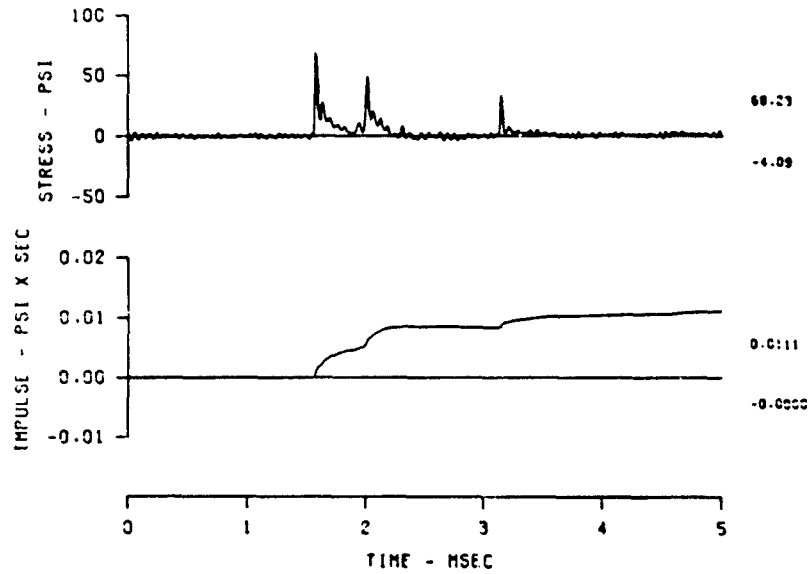


SHOT 15 CH 6 5
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84

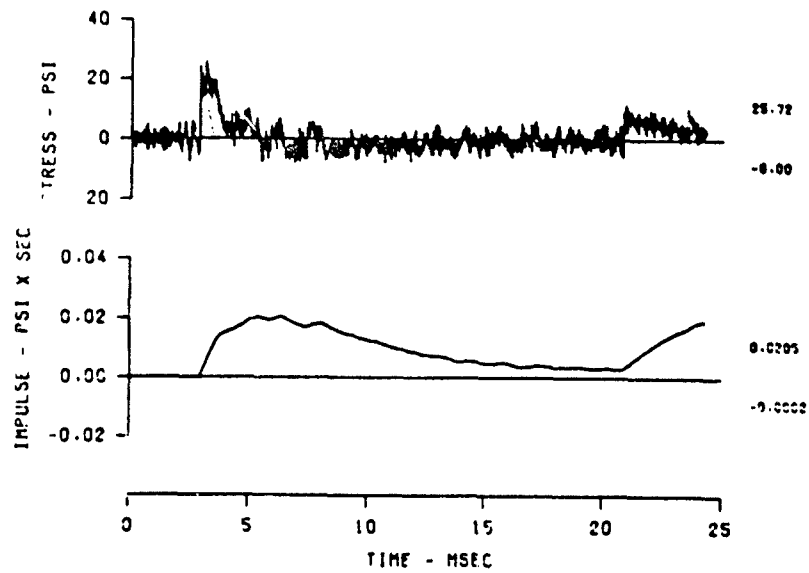


A120

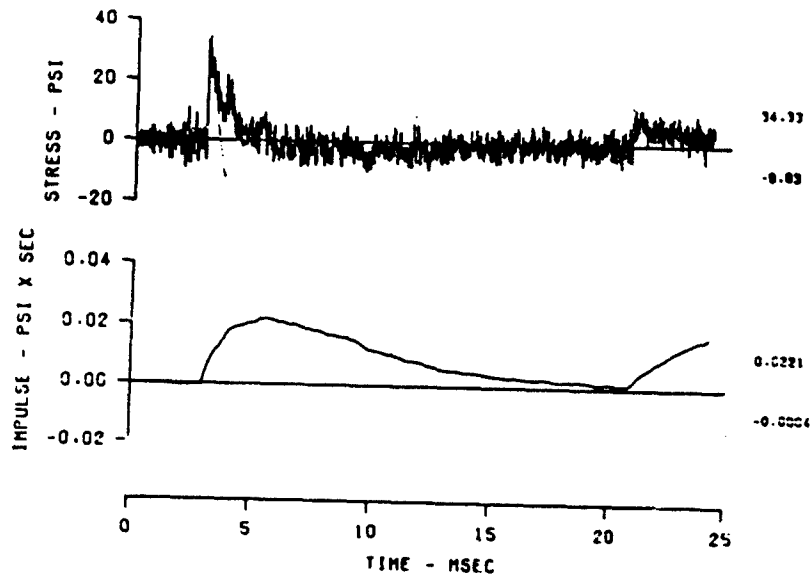
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AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84



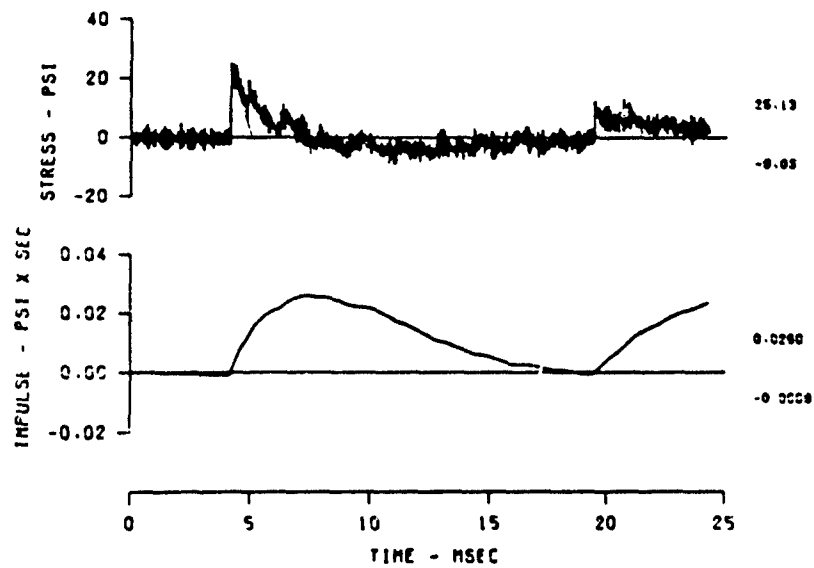
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AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84



SHOT 15 CH 9 8
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84

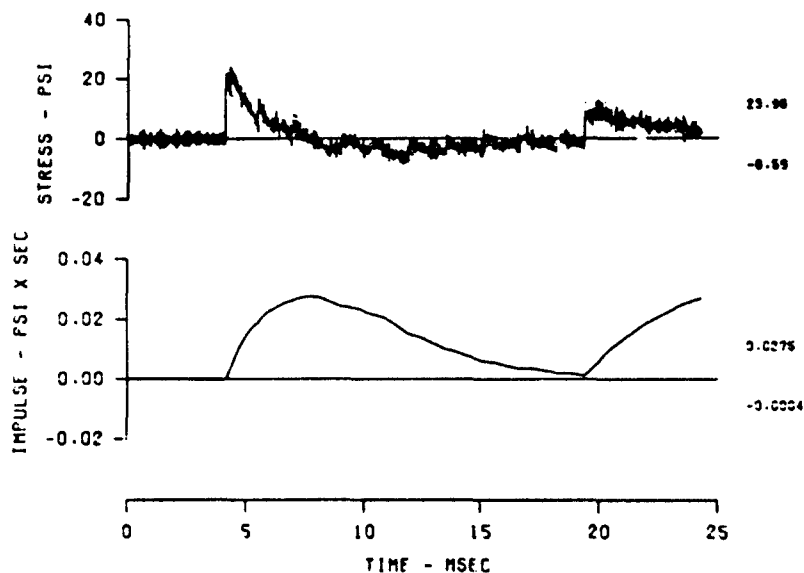


SHOT 15 CH 10 9
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84

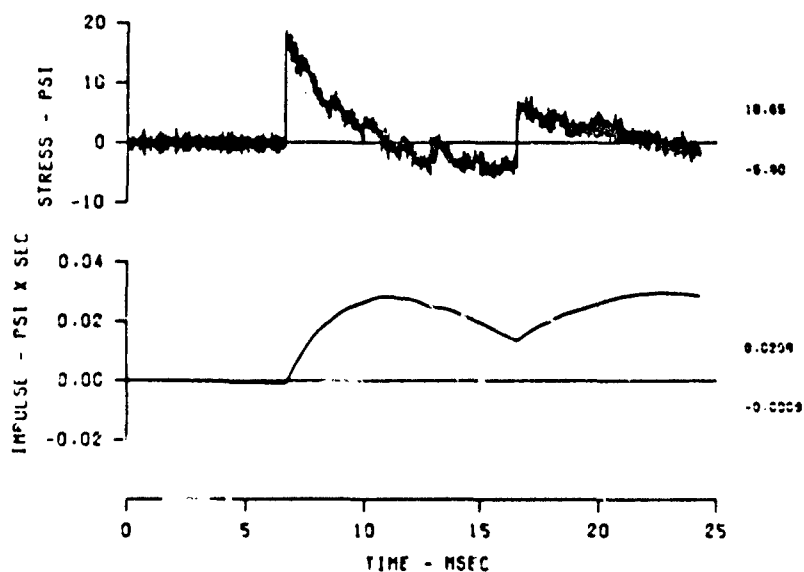


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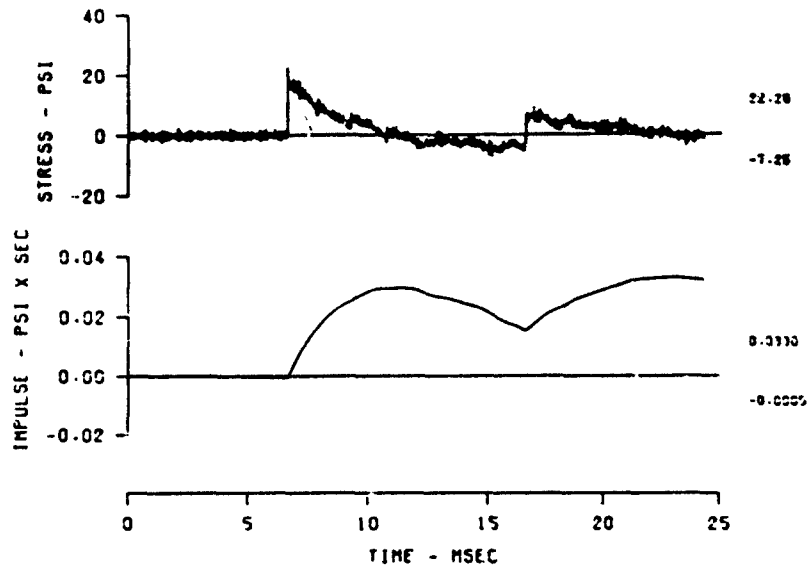
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 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/27/84



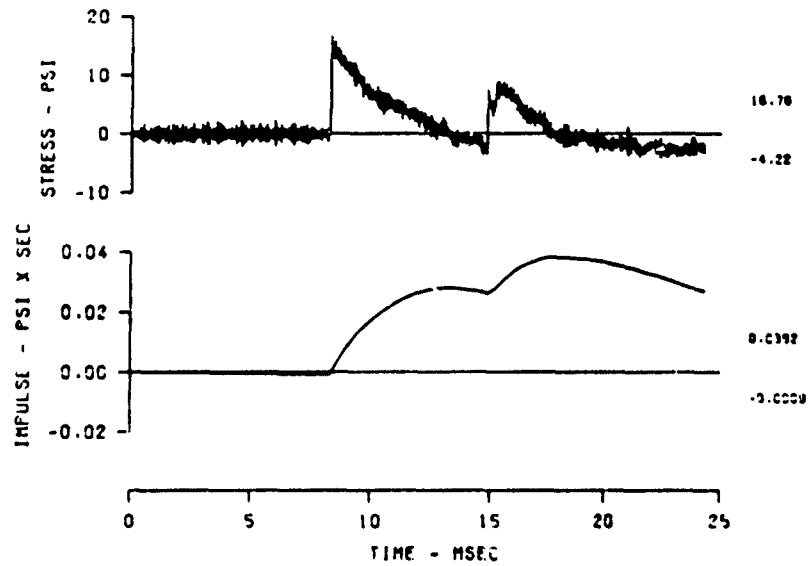
SHOT 15 CH 12 11
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 500000.HZ 02/27/84



SHOT 15 CH 13 12
AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84

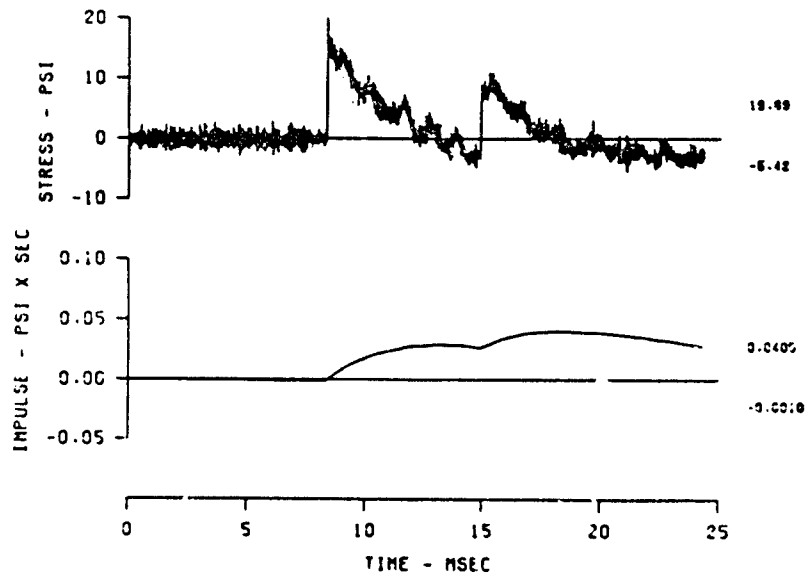


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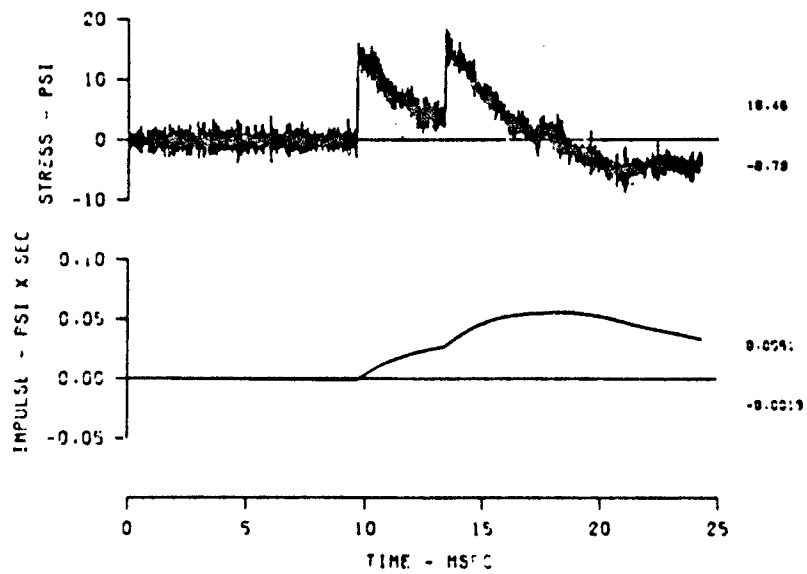


A124

SHOT 15 CH 45 14
 AIRBLAST PENETRATION 1983 LONG SQUARE
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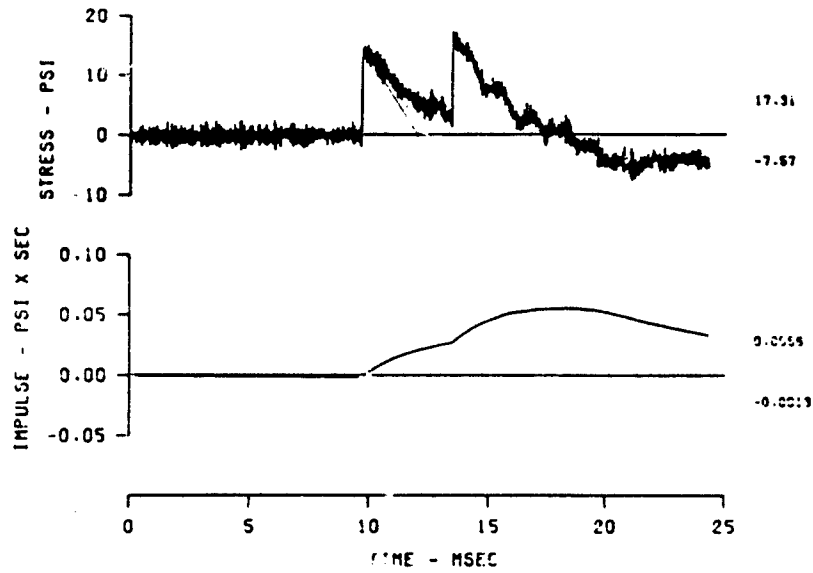


SHOT 15 CH 16 15
 AIRBLAST PENETRATION 1983 LONG SQUARE
 500000.HZ 02/27/84

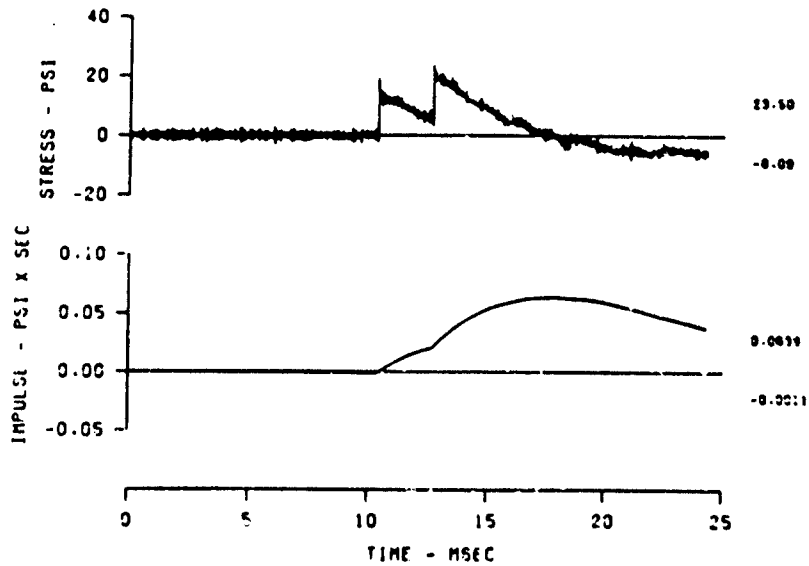


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AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84

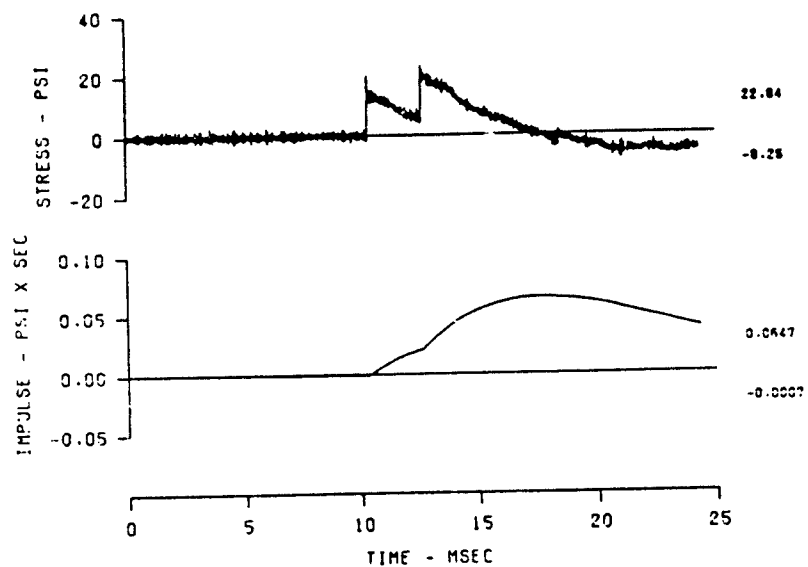


SHOT 15 CH 18 17
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500000.HZ 02/27/84

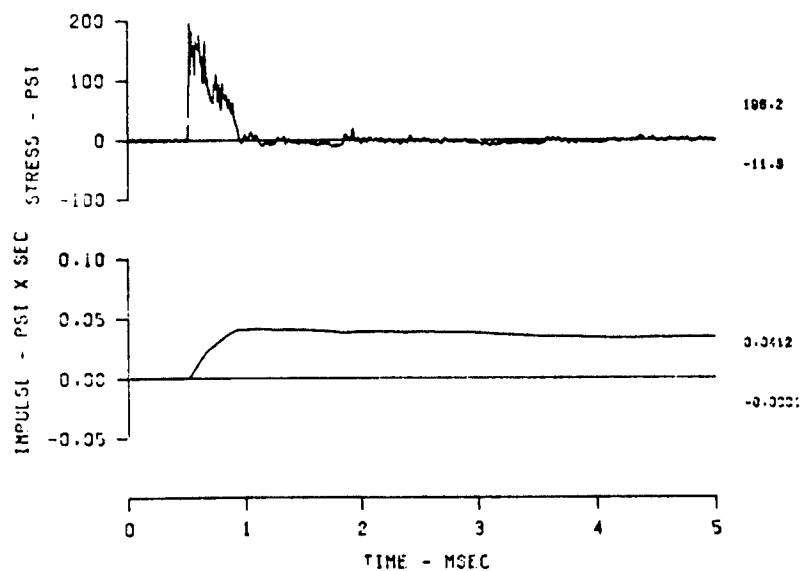


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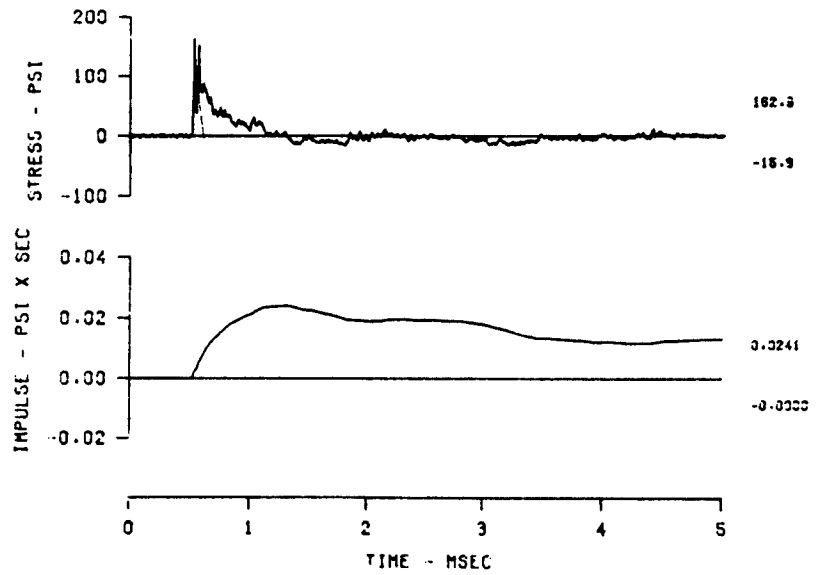
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AIRBLAST PENETRATION 1983 LONG SQUARE
500000.HZ 02/27/84



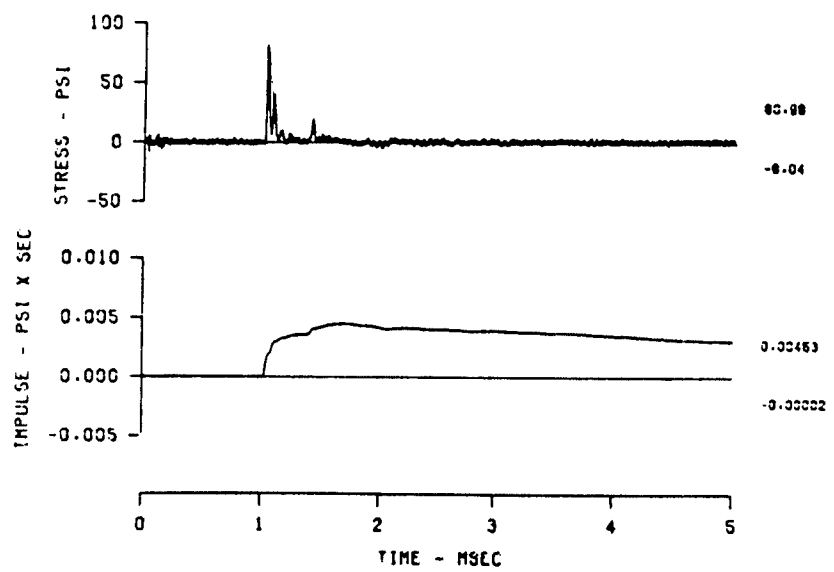
SHOT 16 CH 2 1
AIRBLAST PENETRATION 1983 6 IN TO 1
500000.HZ 02/29/84



SHOT 16 CH 3 2
 AIRBLAST PENETRATION 1983 6 IN TO 1
 500000.HZ 02/29/84

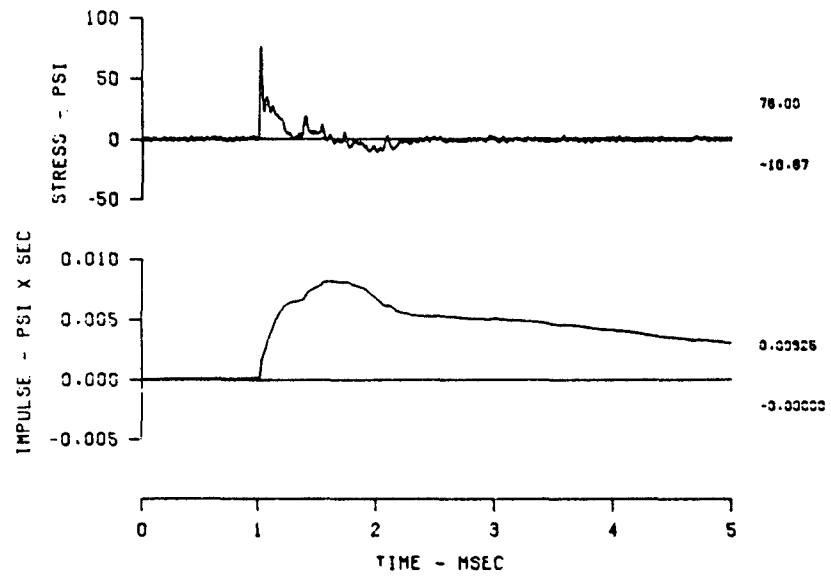


SHOT 16 CH 4 3
 AIRBLAST PENETRATION 1983 6 IN TO 1
 500000.HZ 02/29/84

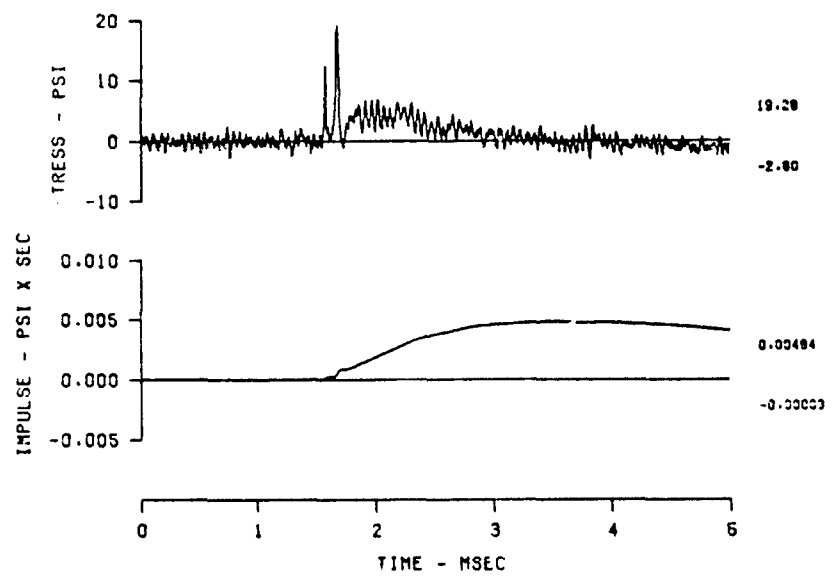


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SHOT 16 CH 5 4
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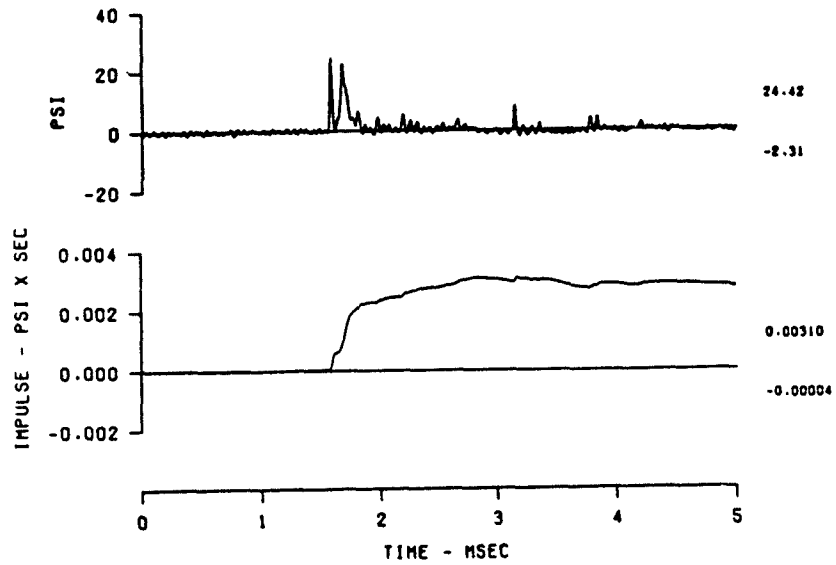


SHOT 16 CH 6 5
AIRBLAST PENETRATION 1983 6 IN TO 1
500000.HZ 02/29/84

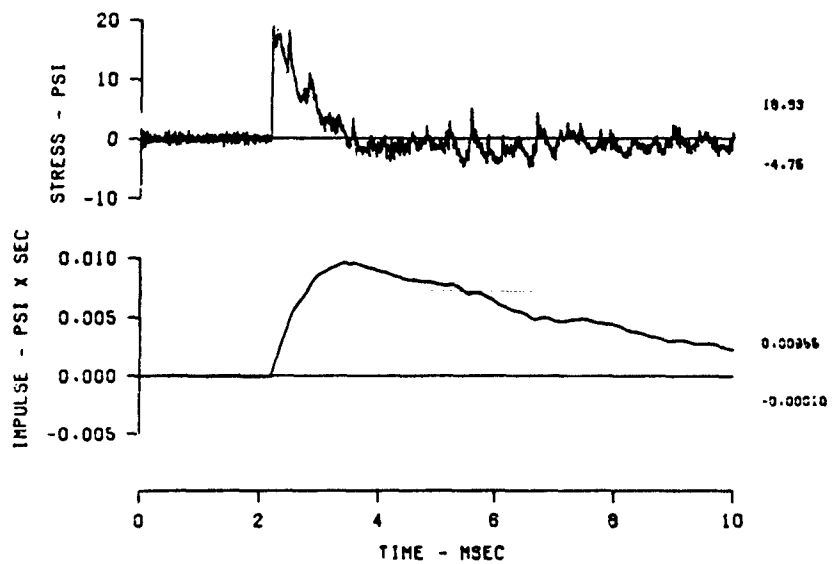


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SHOT 16 CH 7 6
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500000.HZ 06/13/84

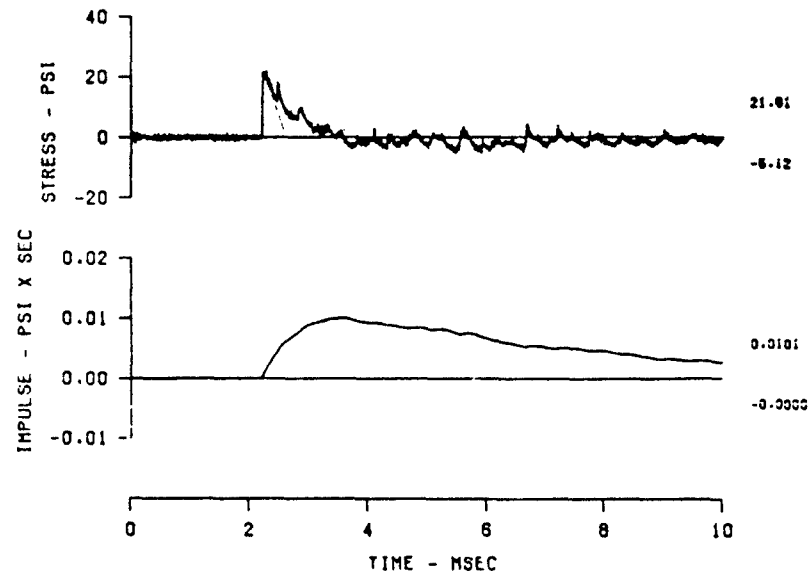


SHOT 18 CH 10 7
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500000.HZ 02/29/84

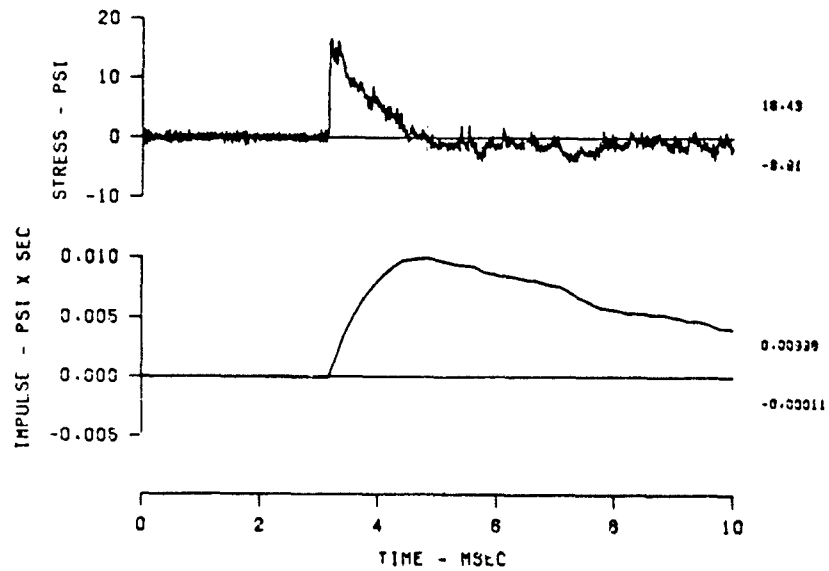


A130

SHOT 18 CH 11 8
AIRBLAST PENETRATION 1983 6 IN TO 1
500000.HZ 02/29/84

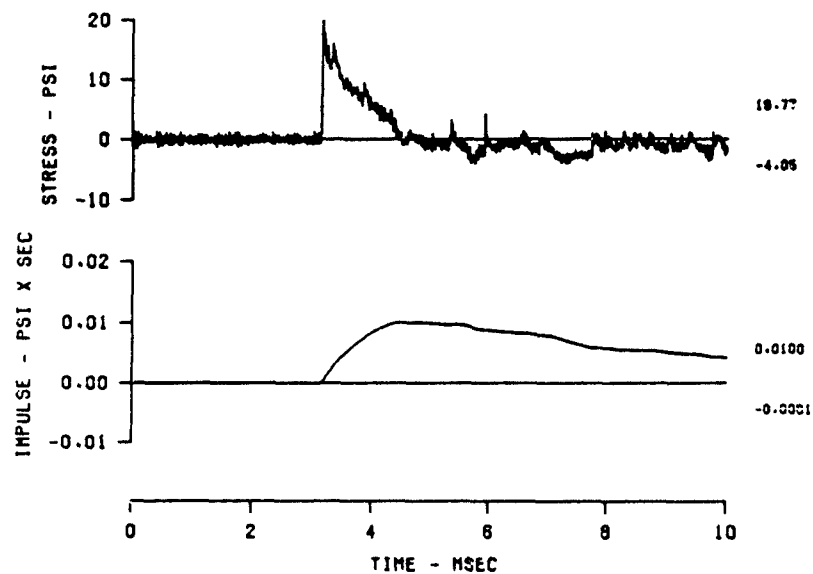


SHOT 18 CH 12 9
AIRBLAST PENETRATION 1983 6 IN TO 1
500000.HZ 02/29/84

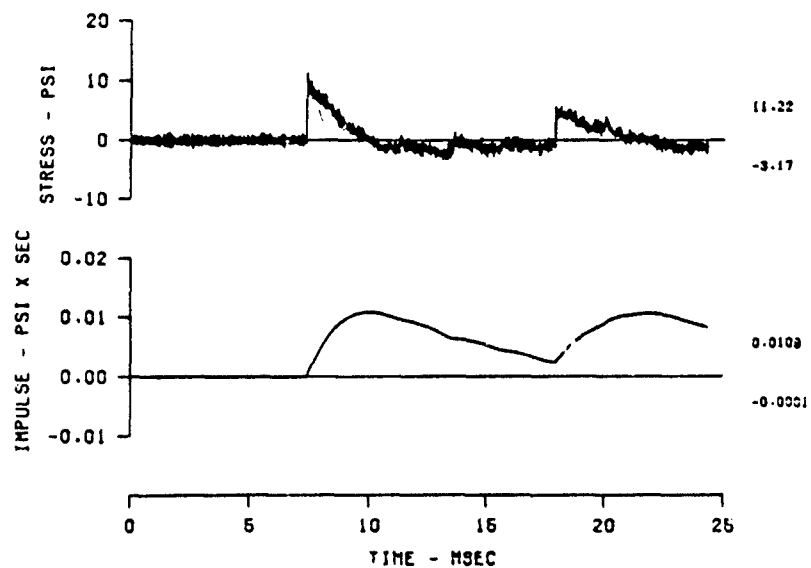


A131

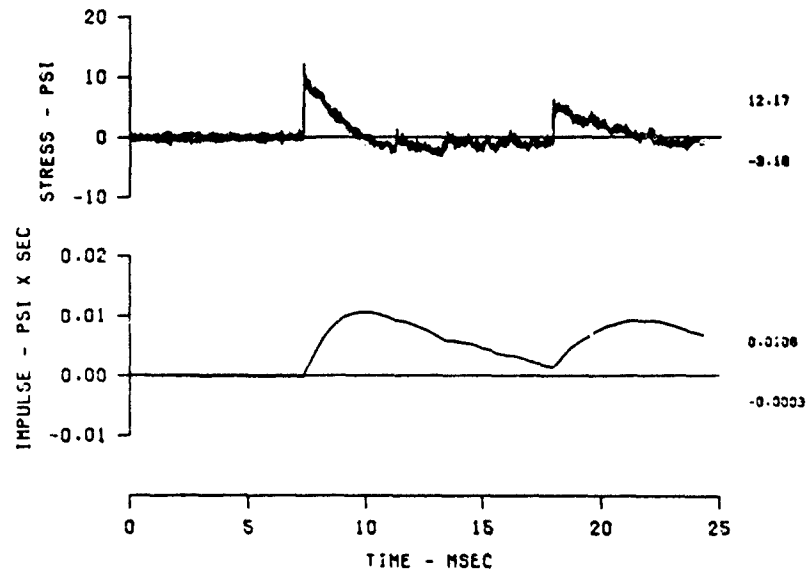
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 500000.HZ 02/29/84



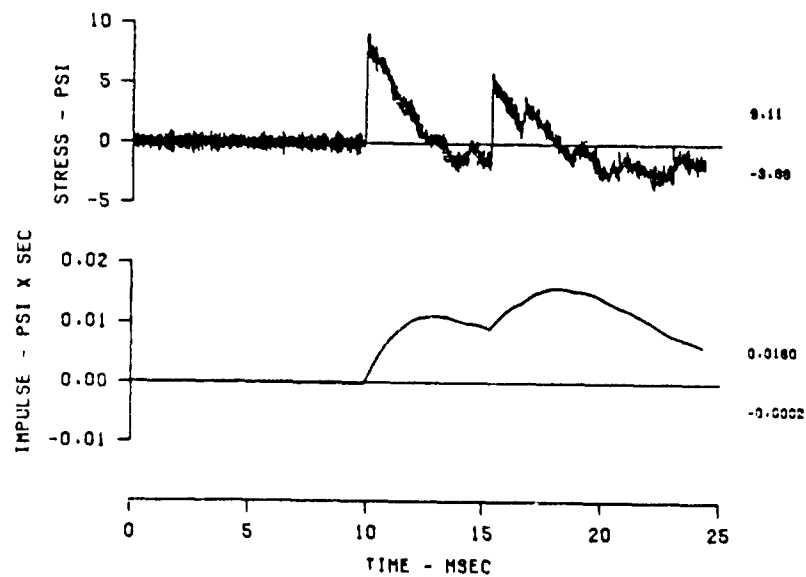
SHOT 16 CH 14 11
 AIRBLAST PENETRATION 1983 6 IN TO 1
 500000.HZ 02/29/84



SHOT 16 CH 15 12
AIRBLAST PENETRATION 1983 6 IN TO 1
500000.HZ 02/29/84



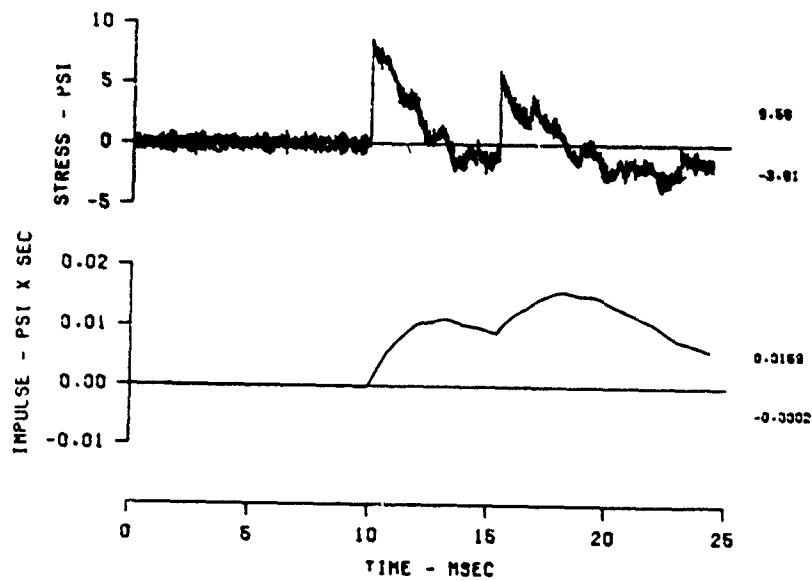
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500000.HZ 02/29/84



A133

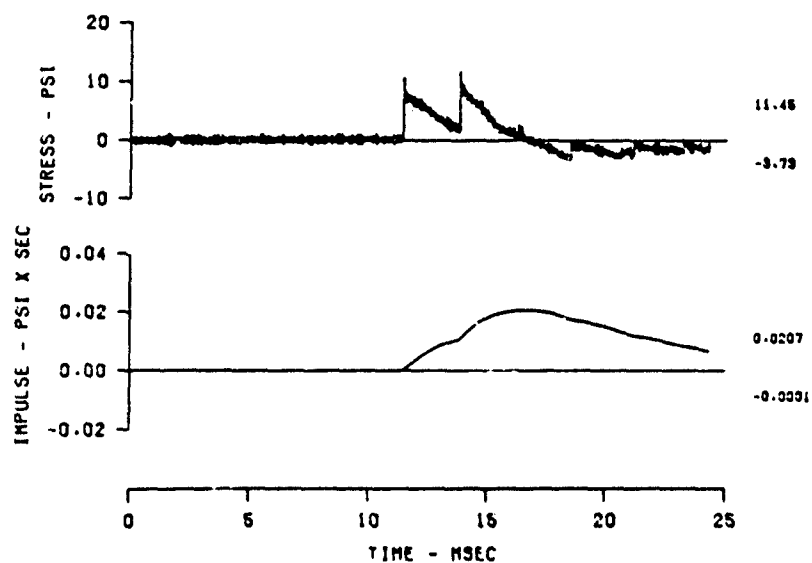
SHOT 16 CH 17 14
AIRBLAST PENETRATION 1983
500000.HZ 02/29/84

6 IN TO 1



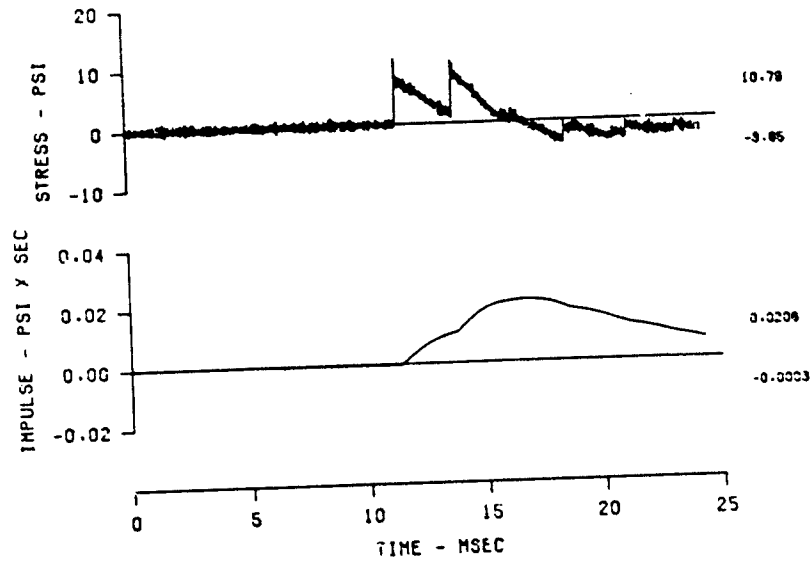
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AIRBLAST PENETRATION 1983
500000.HZ 02/29/84

6 IN TO 1

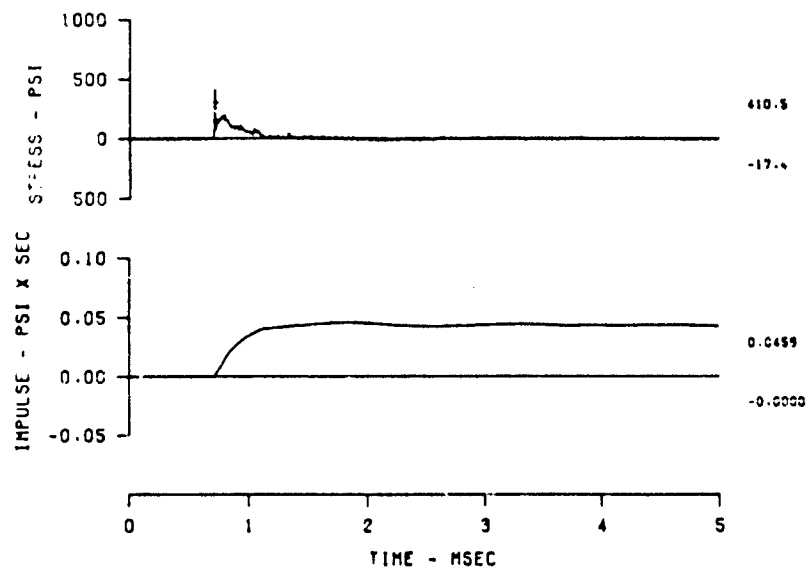


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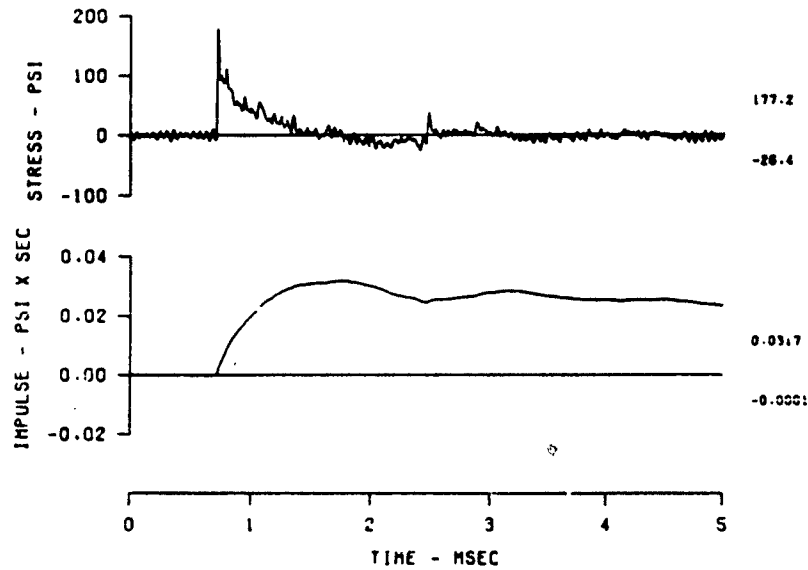
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 500000.HZ 02/29/84



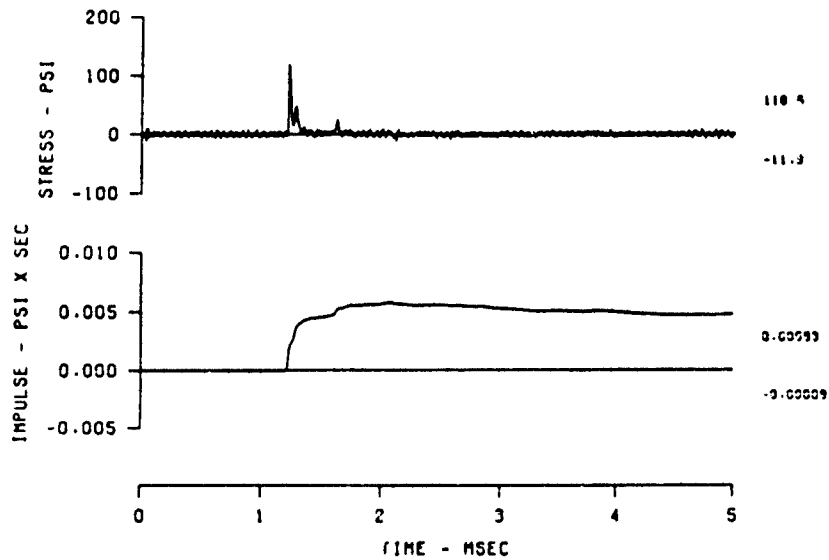
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 500000.HZ 02/27/84



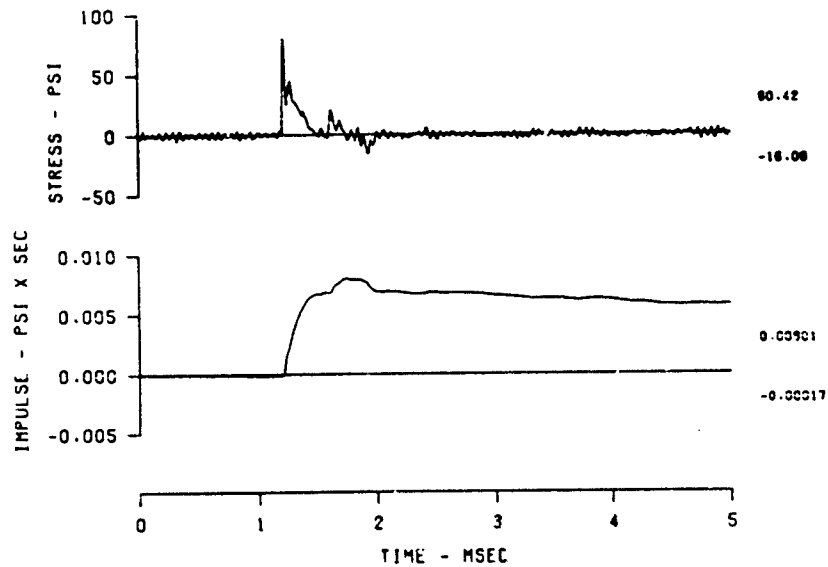
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500000.HZ 02/27/84



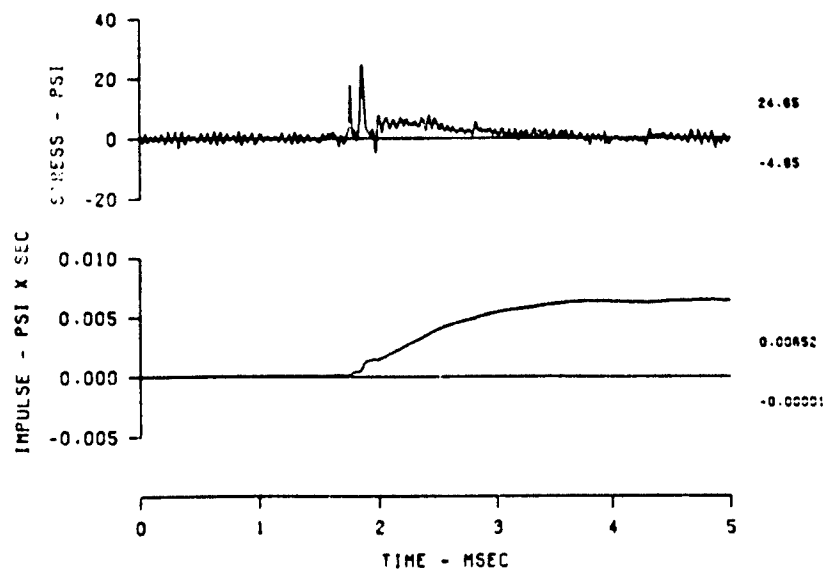
SHOT 17 CH 4 3
AIRBLAST PENETRATION 1983 6 IN TO 1
500000.HZ 02/27/84



SHOT 17 CH 5 4
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500000.HZ 02/27/84

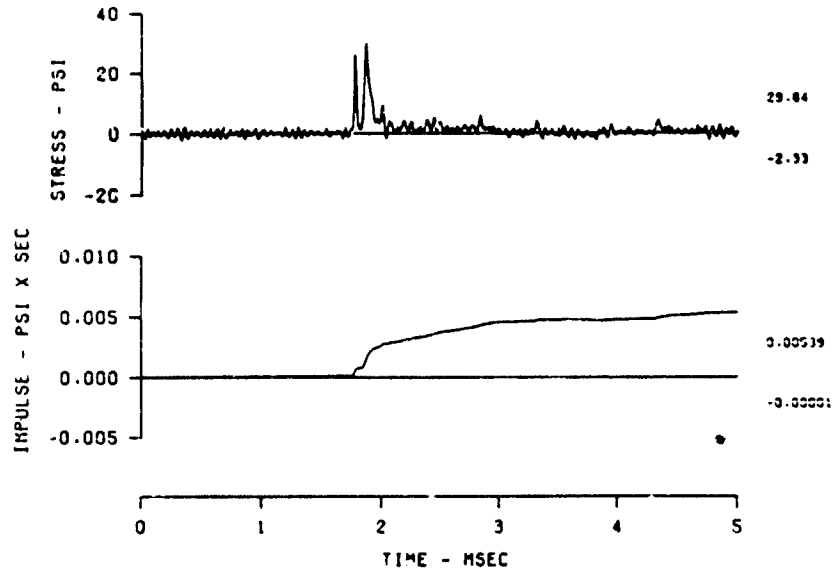


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500000.HZ 02/27/84

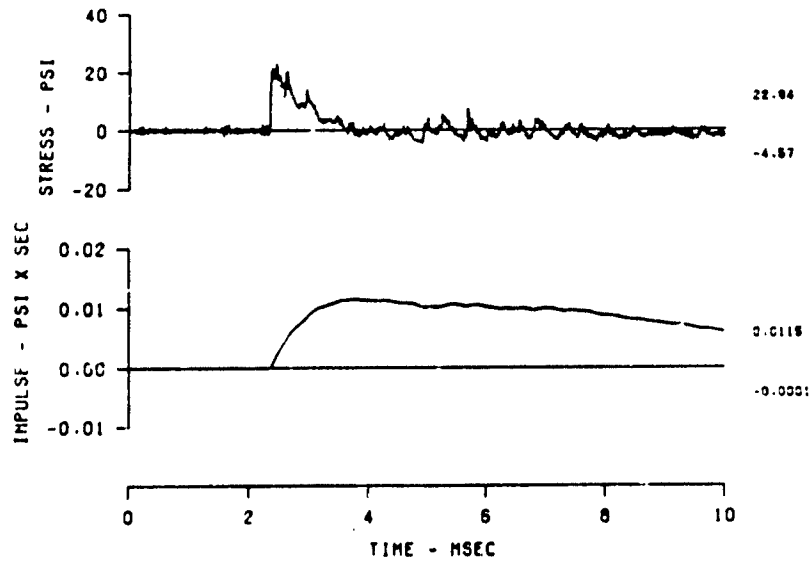


A137

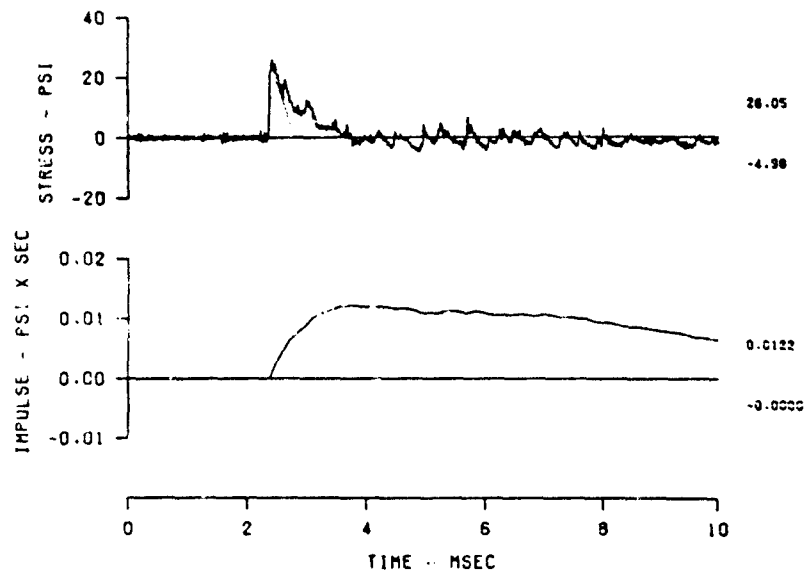
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 500000.HZ 02/27/84



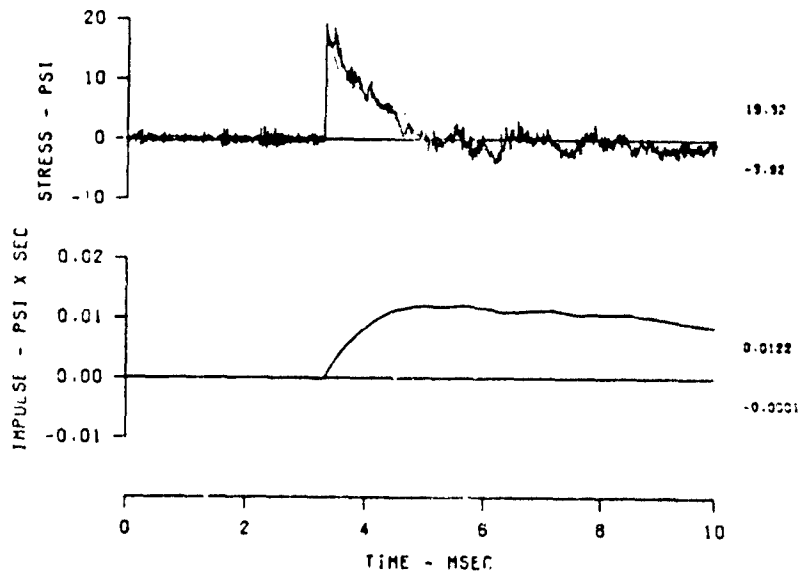
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 500000.HZ 02/27/84



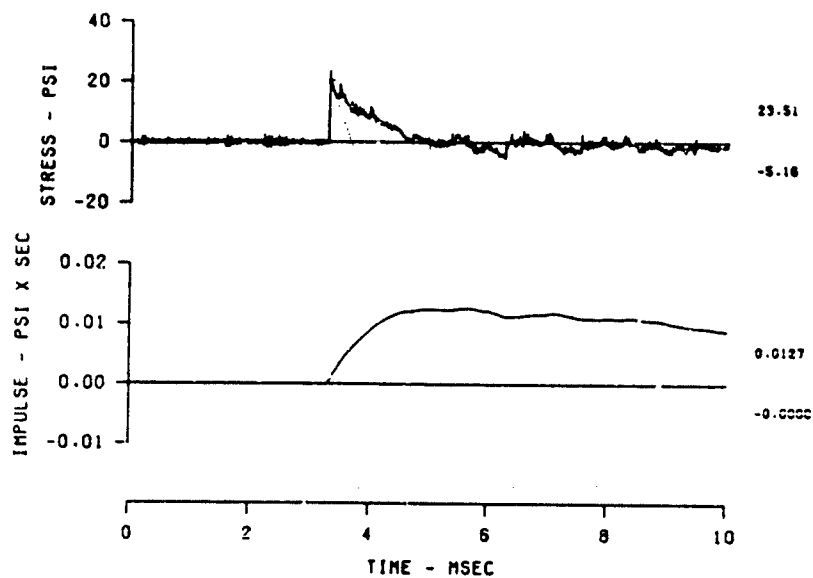
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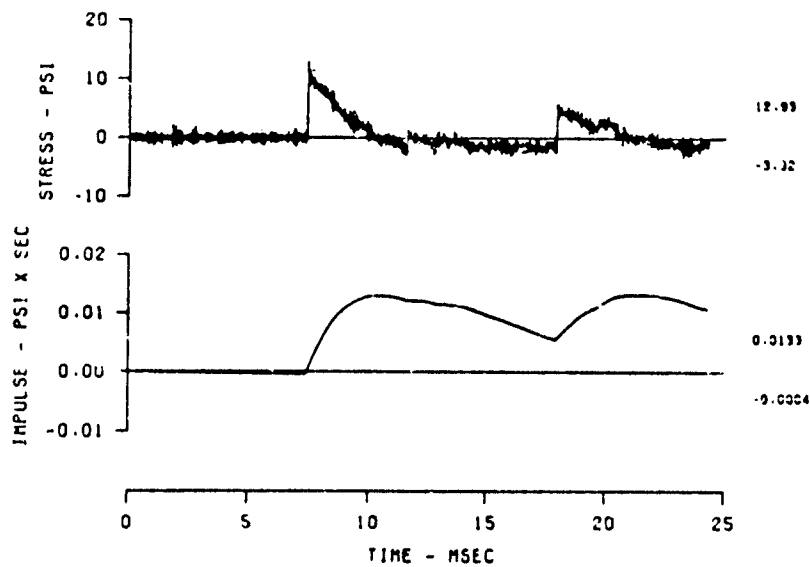
SHOT 17 CH 12 9
 AIRBLAST PENETRATION 1983 6 IN TO 1
 500000.HZ 02/27/84



SHOT 17 CH 13 10
 AIRBLAST PENETRATION 1983 6 IN 10 1
 500000.HZ 02/27/84

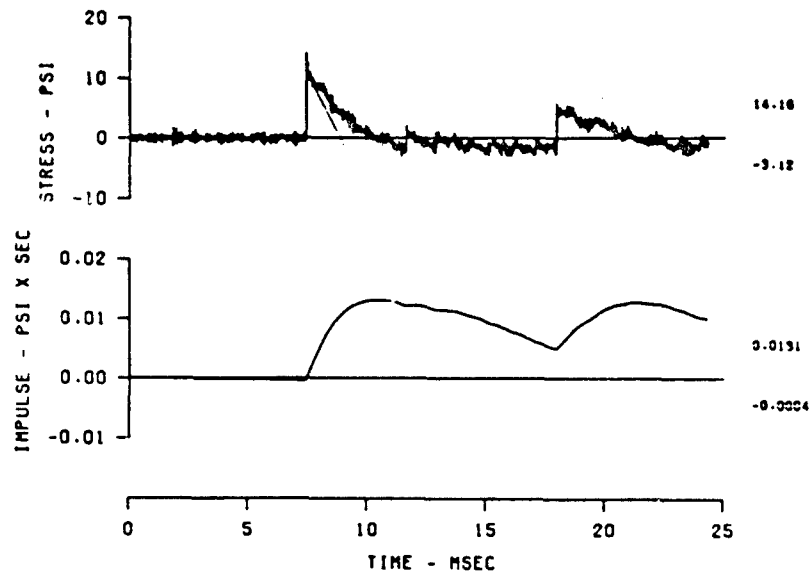


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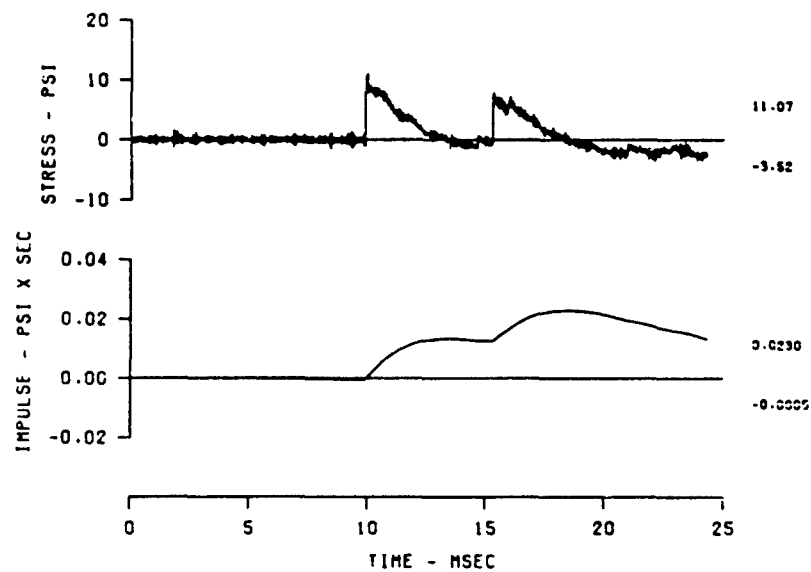


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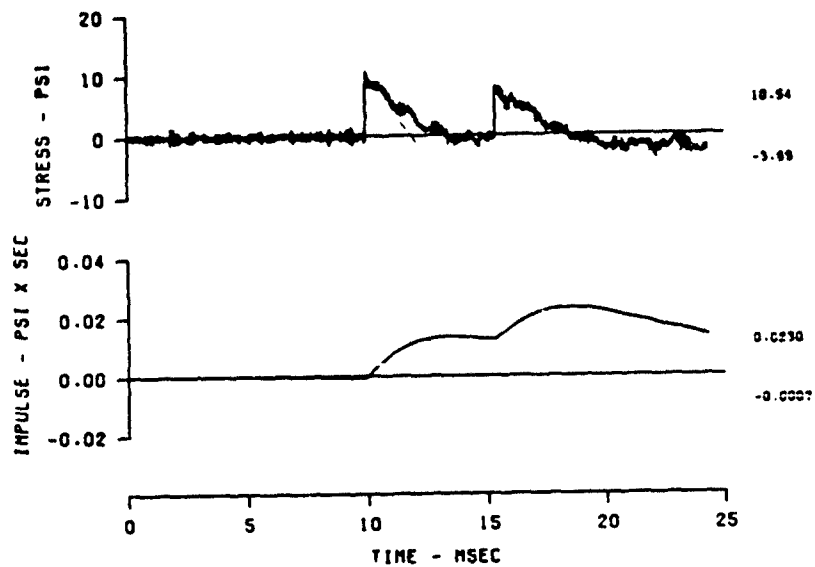
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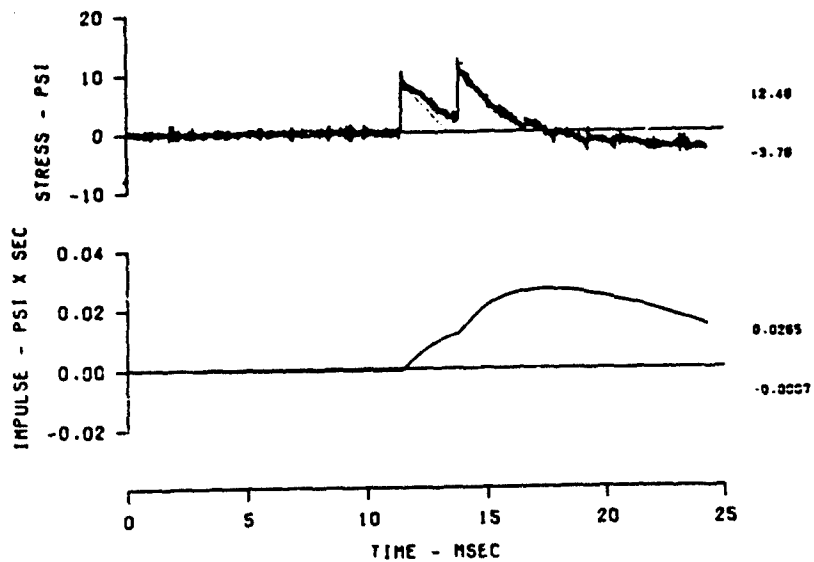
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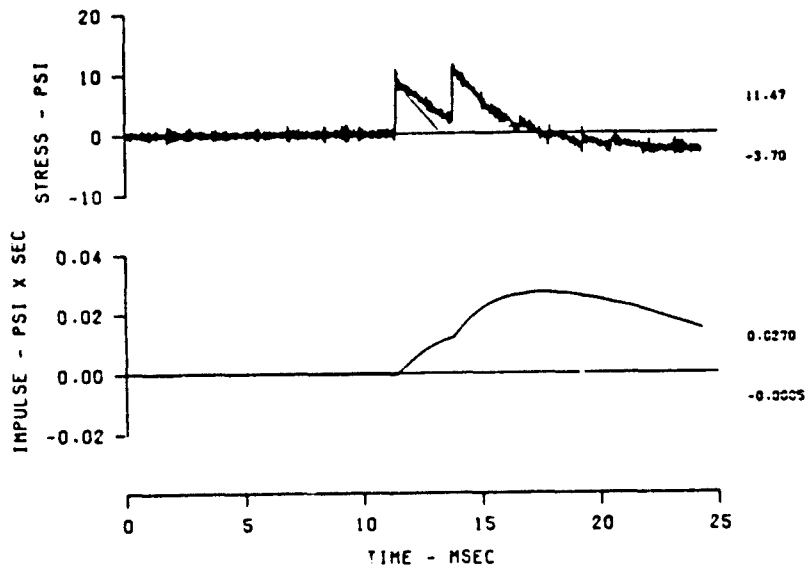
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 500000.HZ 02/27/84



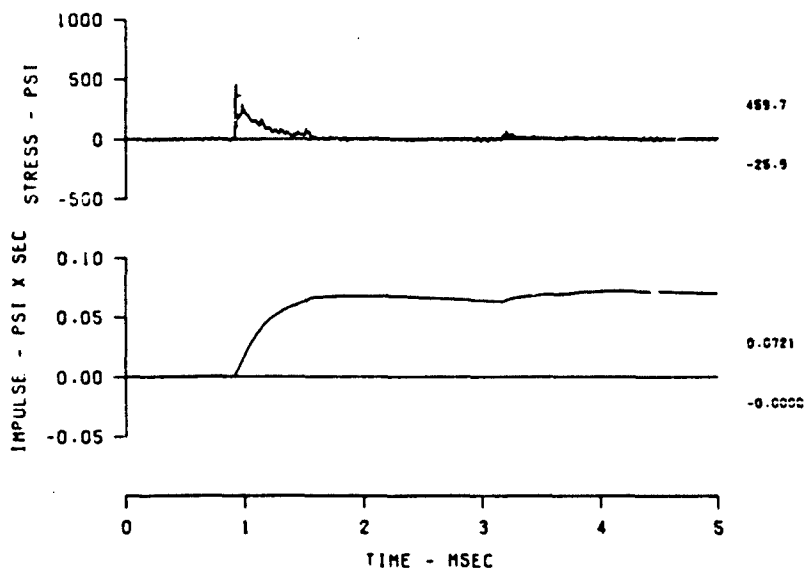
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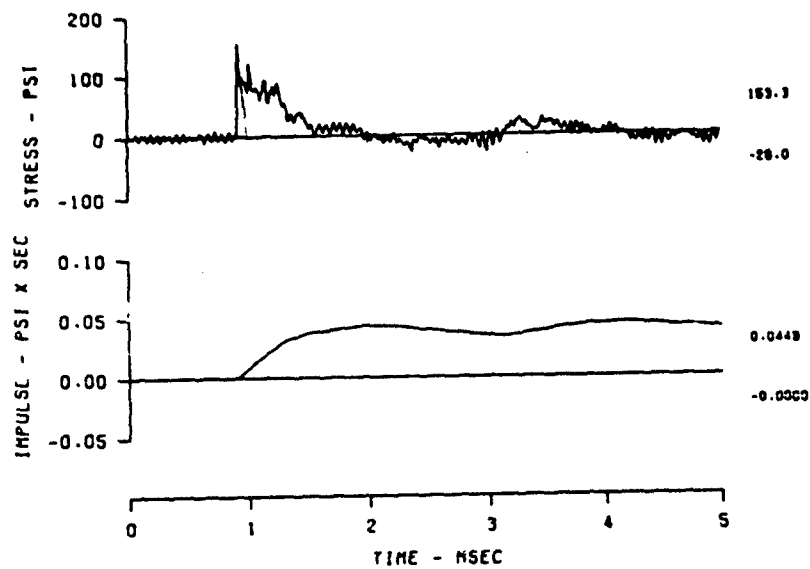
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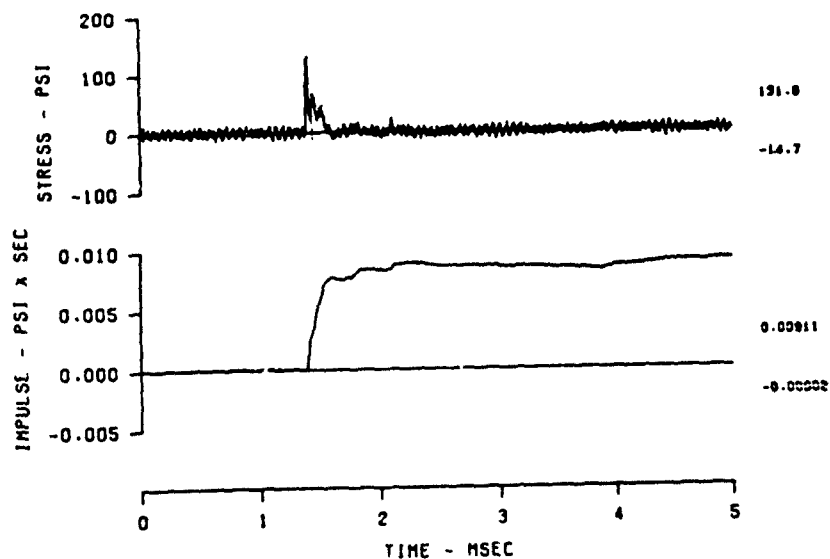
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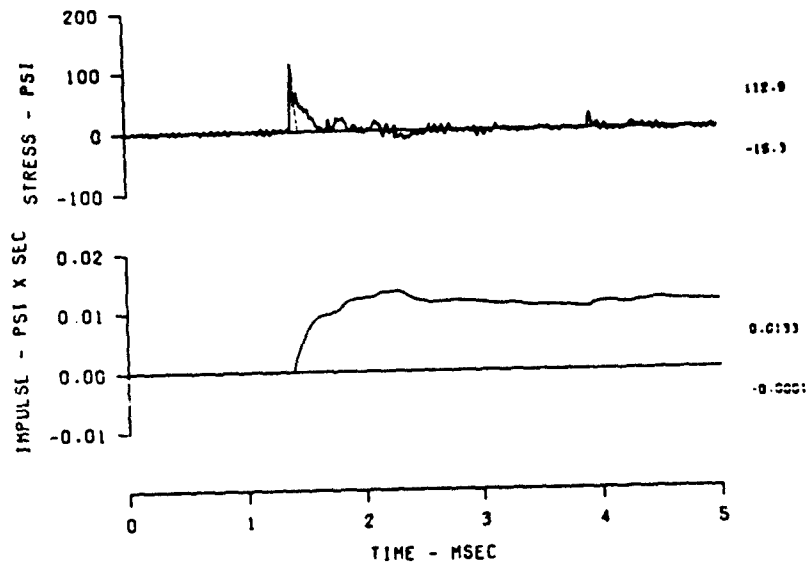
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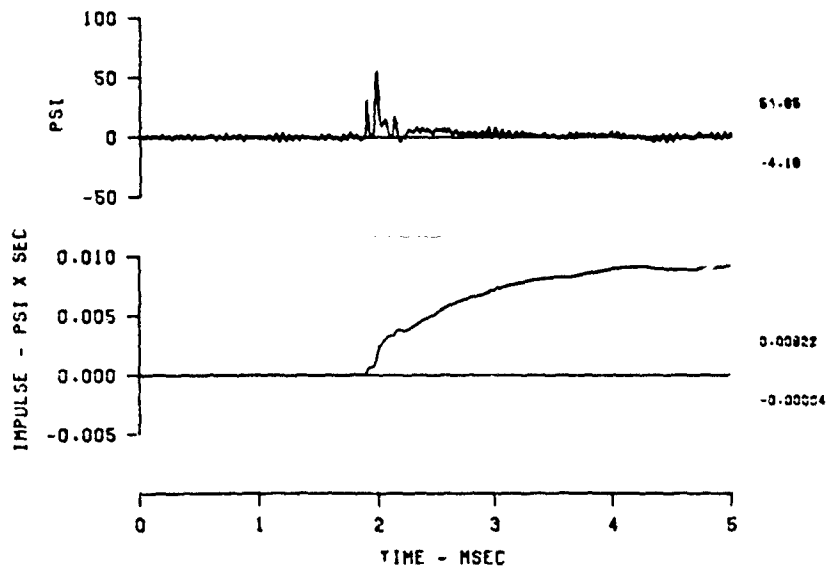
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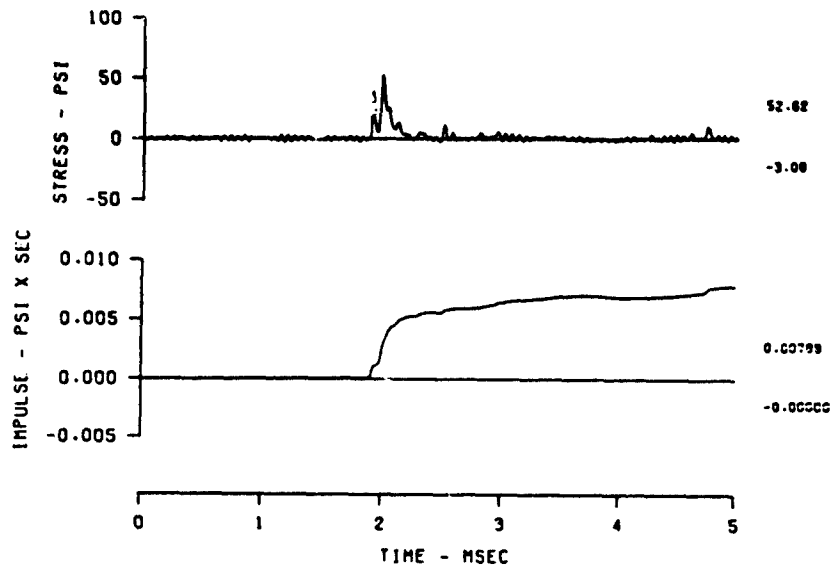
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 500000.HZ 02/27/84



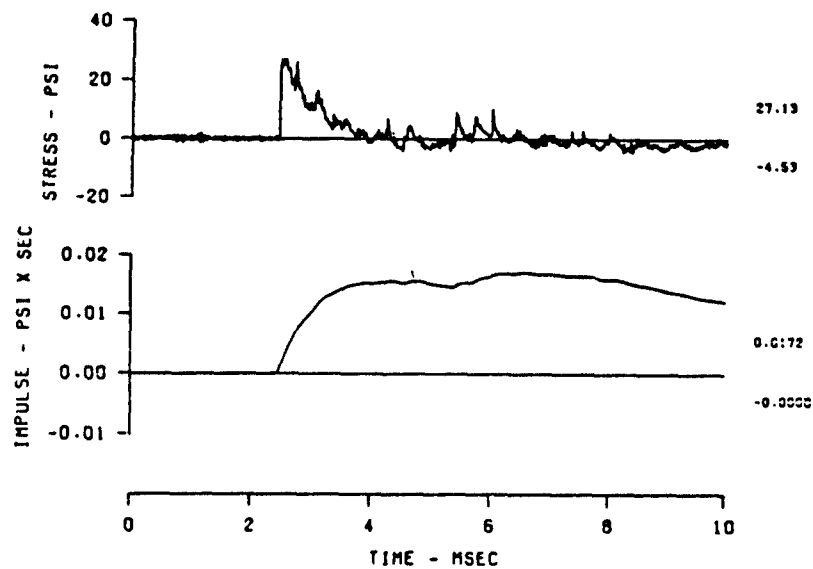
SHOT 19 CH 5 5
 AIRBLAST PENETRATION 1983 6 IN TO 12 IN
 500000.HZ 03/12/84



SHOT 18 CH 7 6
 AIRBLAST PENETRATION 1983 6 IN TO 1
 500000.HZ 02/27/84

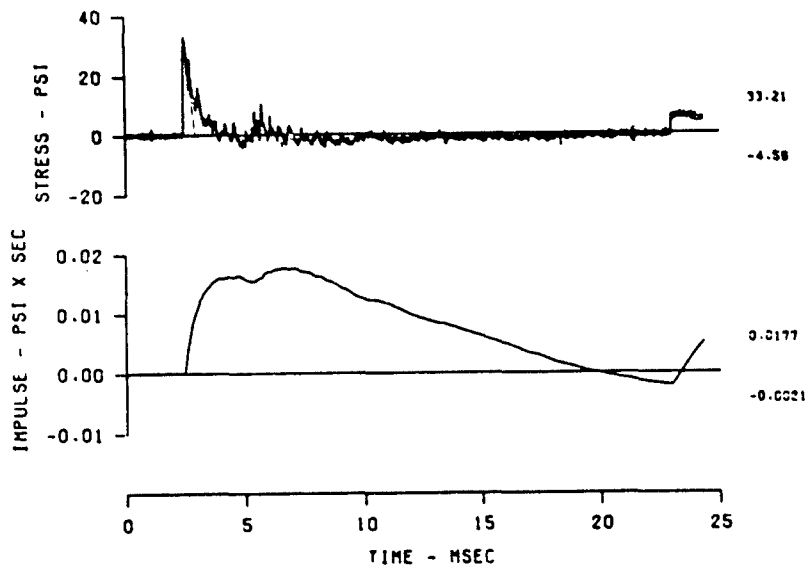


SHOT 18 CH 10 7
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 500000.HZ 02/27/84

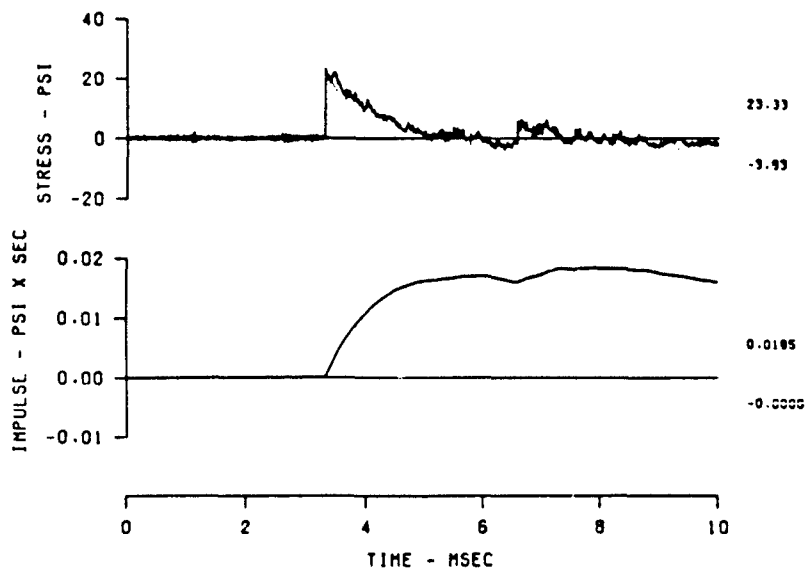


A146

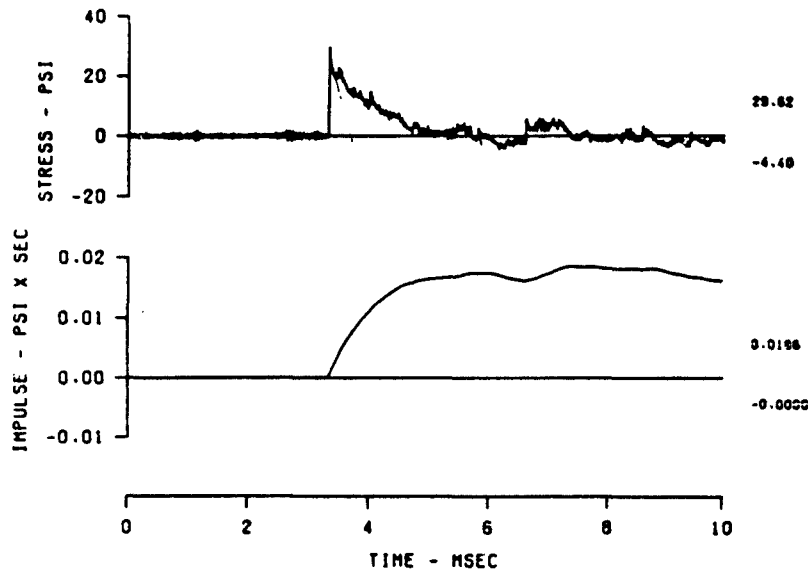
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500000.HZ 02/27/84



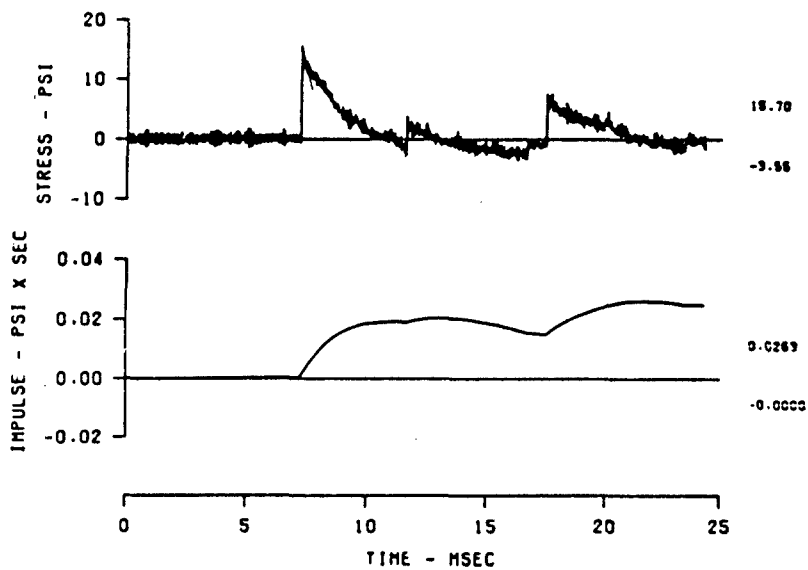
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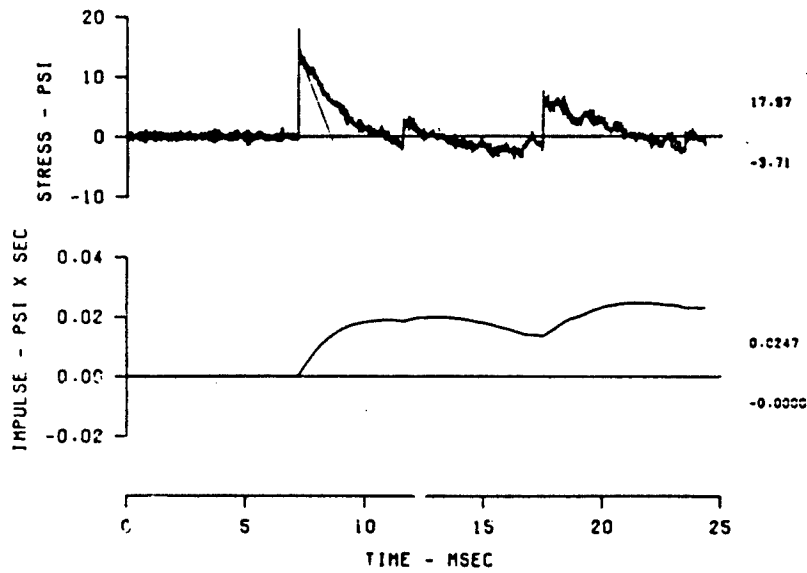
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500000.HZ 02/27/84



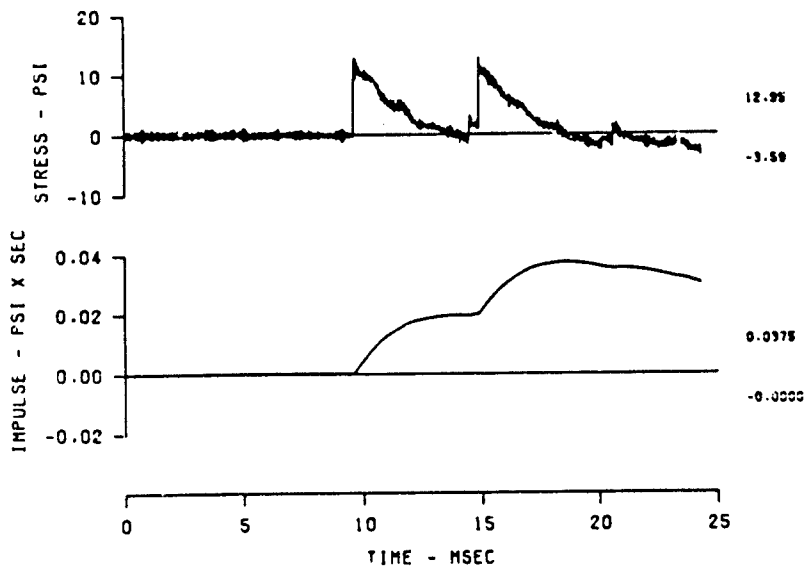
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500000.HZ 02/27/84



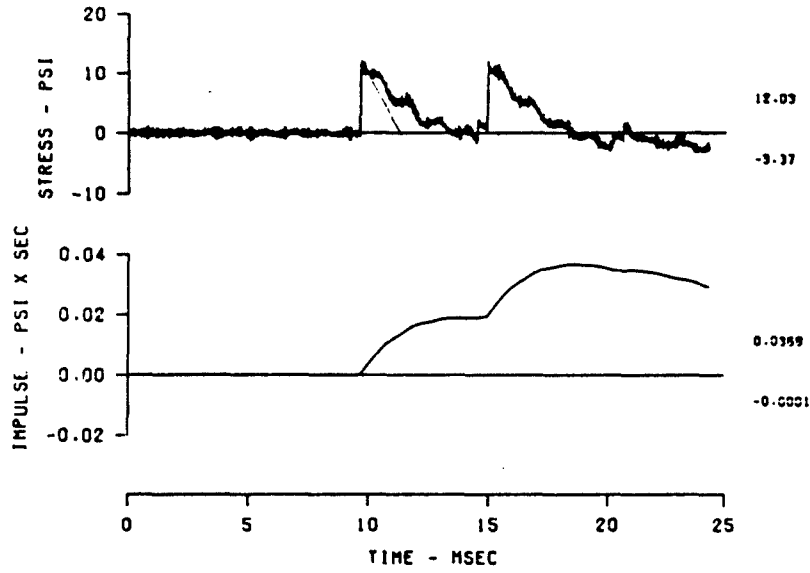
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 500000.HZ 02/27/84



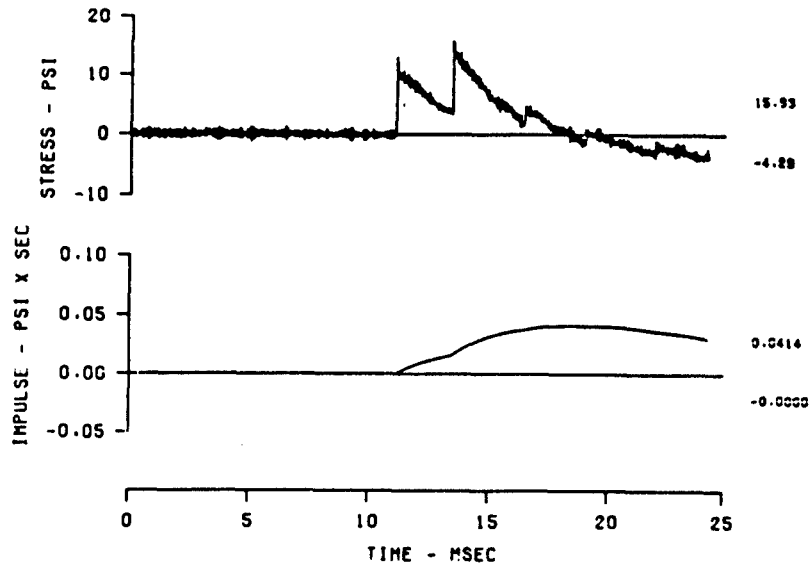
SHOT 18 CH 15 13
 AIRBLAST PENETRATION 1983 6 IN TO 1
 500000.HZ 02/27/84



SHOT 18 CH 17 14
 AIRBLAST PENETRATION 1983 6 IN TO 1
 500000.HZ 02/27/84

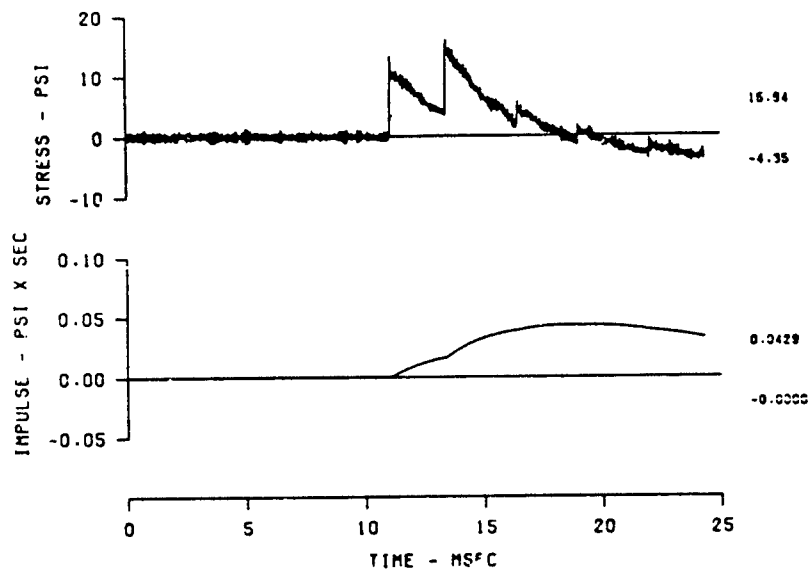


SHOT 18 CH 18 15
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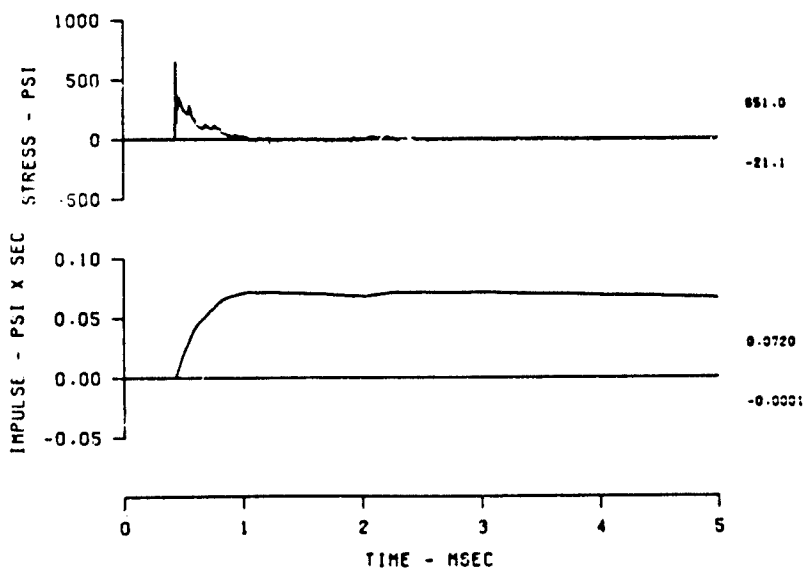


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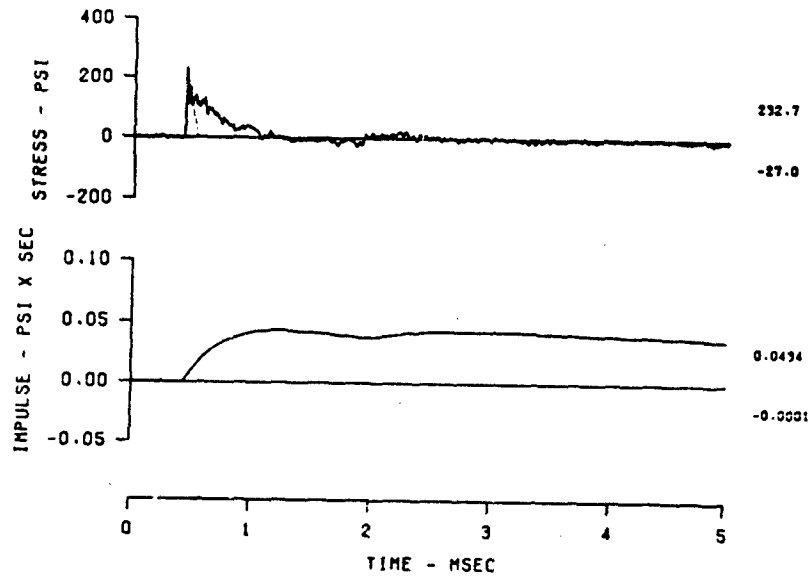
SHOT 18 CH 19 16
 AIRBLAST PENETRATION 1983 6 IN TO 1
 500000.HZ 02/27/84



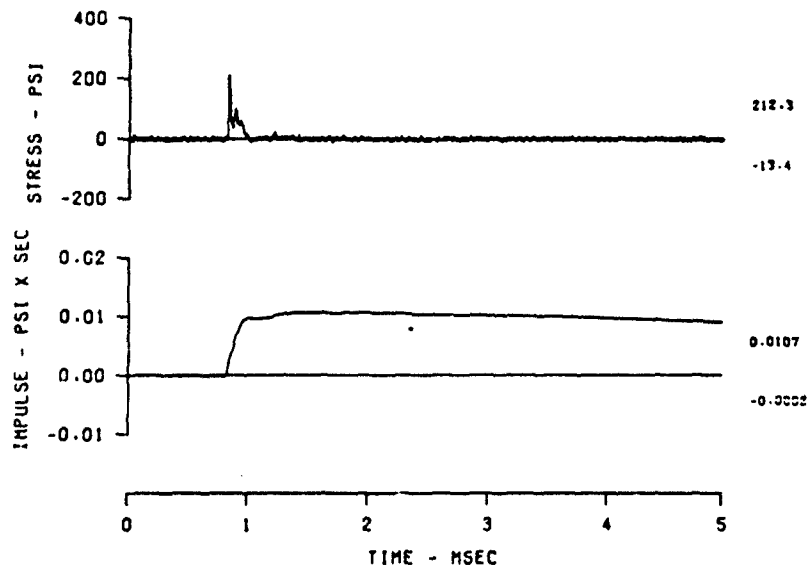
SHOT 19 CH 2 1
 AIRBLAST PENETRATION 1983 6 IN TO 1
 500000.HZ 02/27/84



SHOT 19 CH 3 2
AIRBLAST PENETRATION 1983 6 IN TO 1
500000.HZ 02/27/84

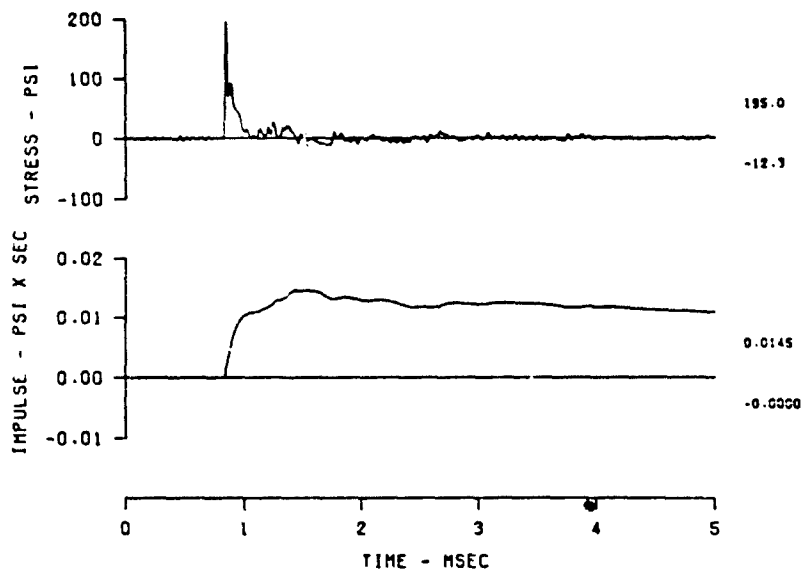


SHOT 19 CH 4 3
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500000.HZ 02/27/84

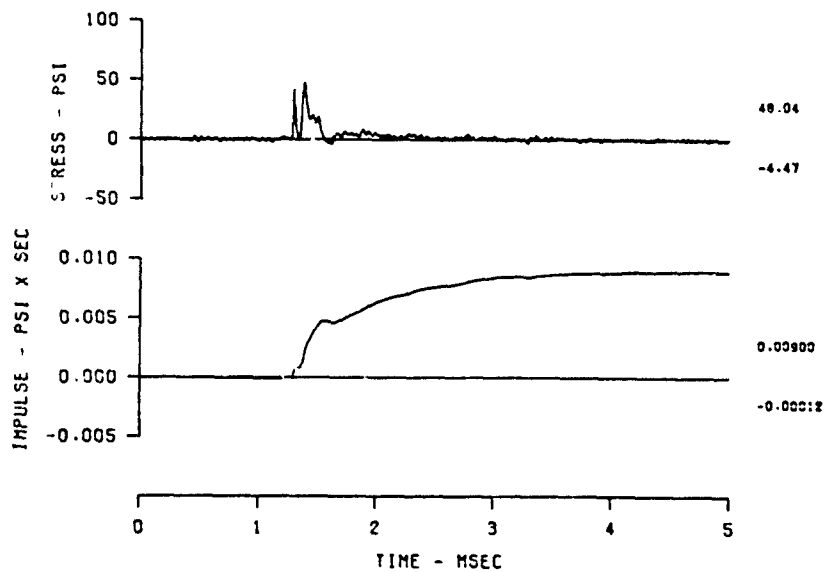


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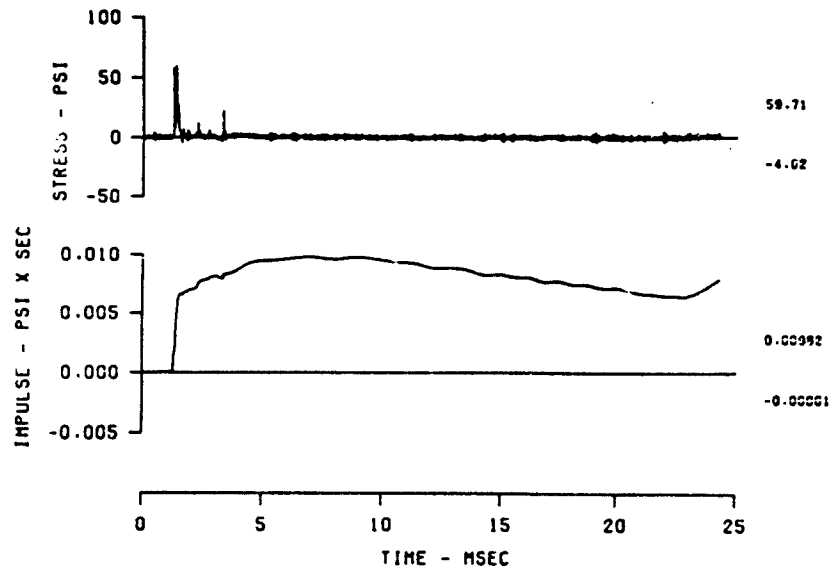
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 AIRBLAST PENETRATION 1983 6 IN TO 1
 500000.HZ 02/27/84



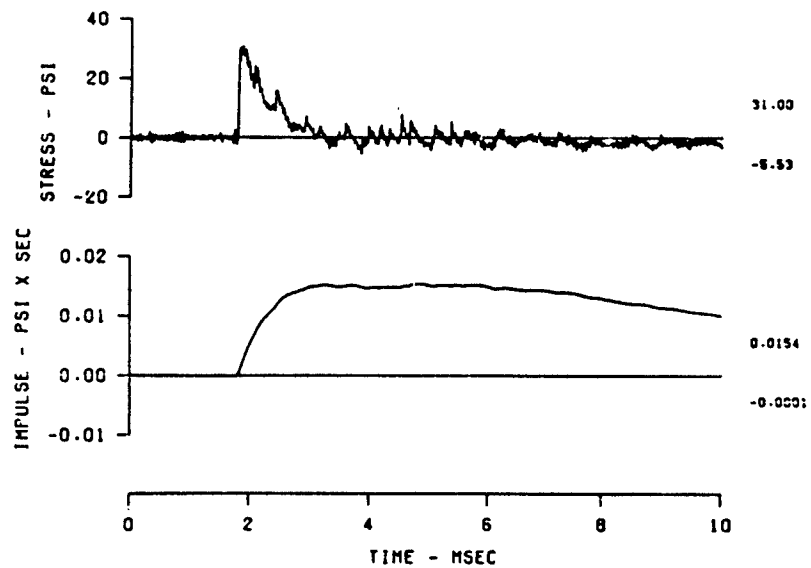
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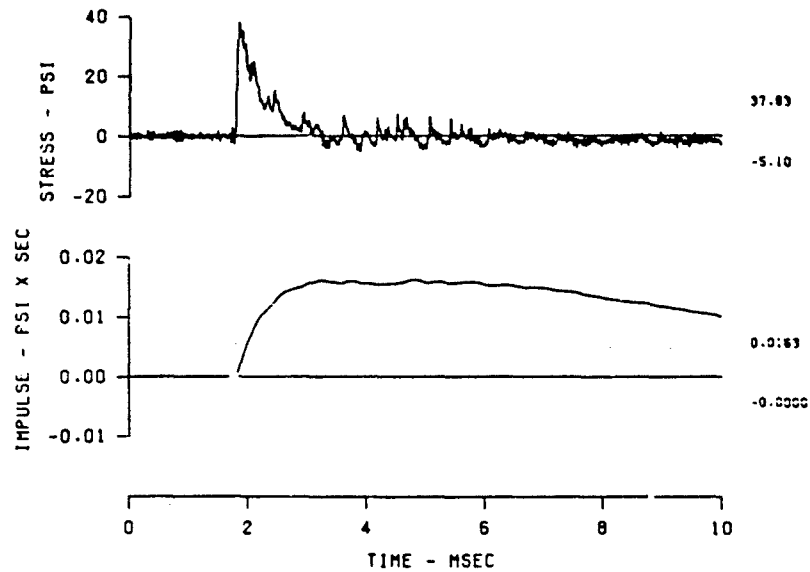
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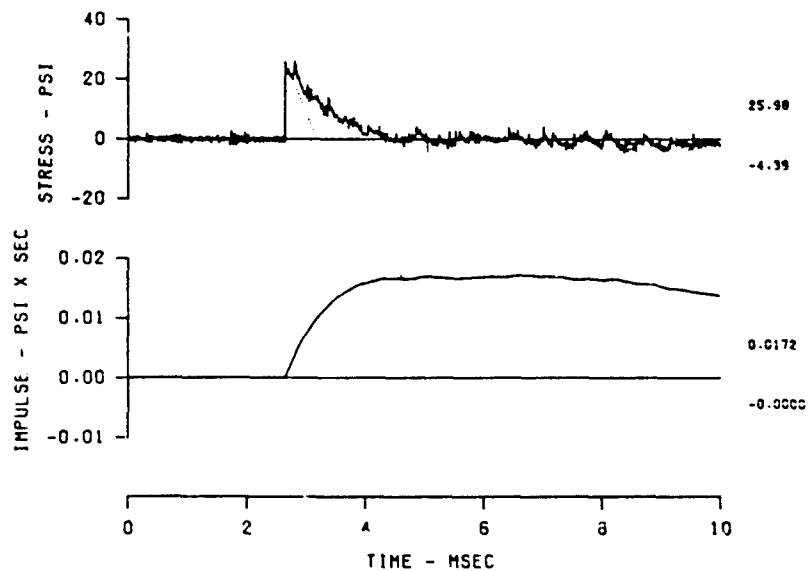
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500000.HZ 02/27/84



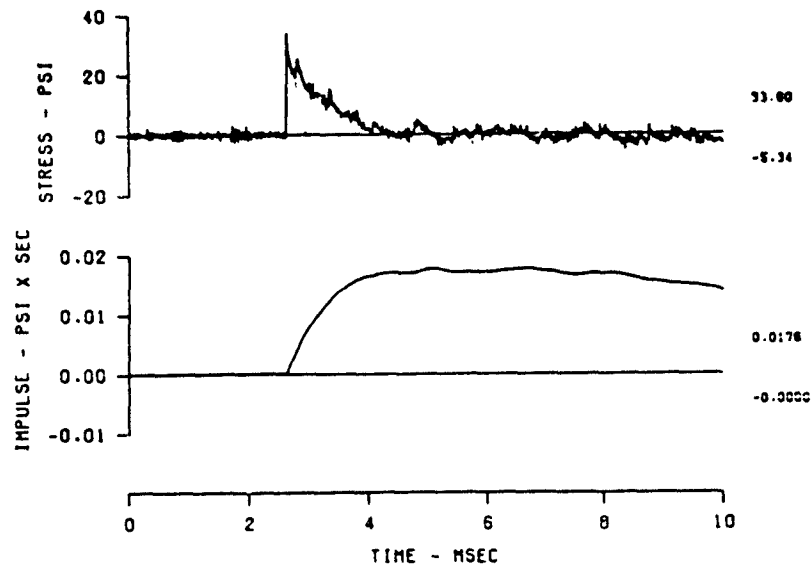
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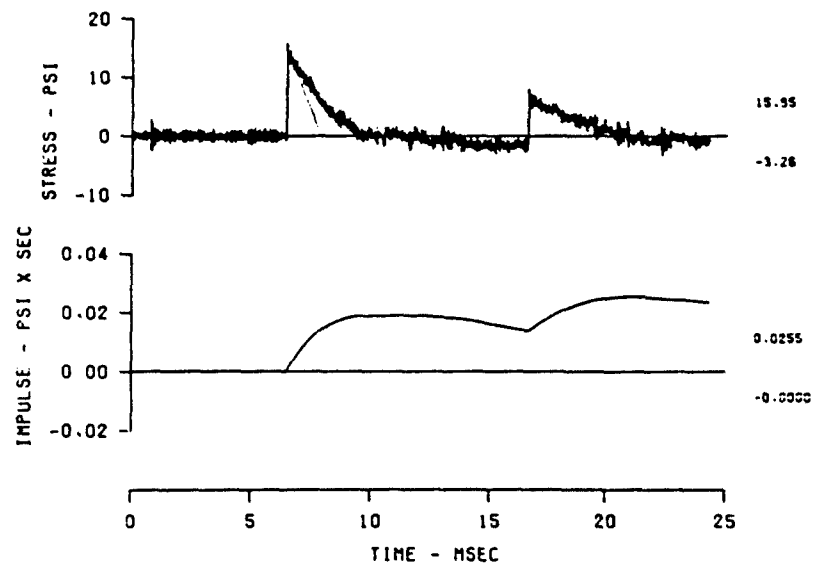
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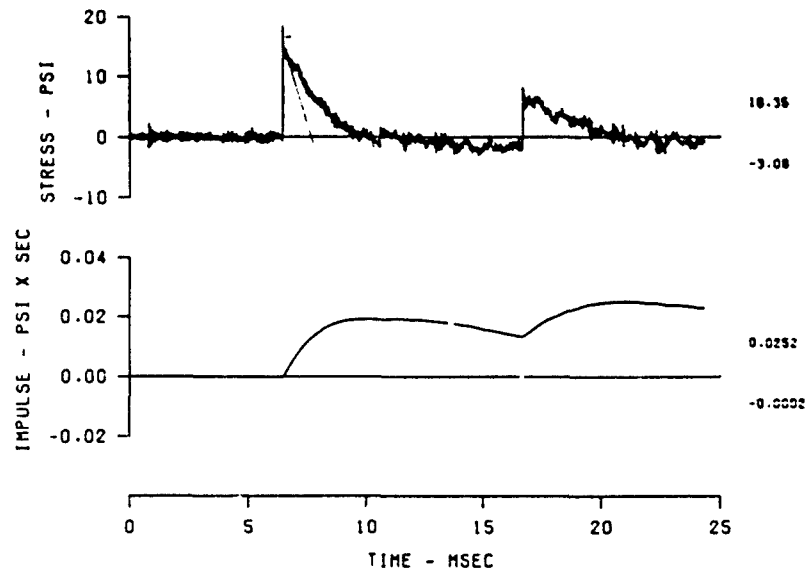
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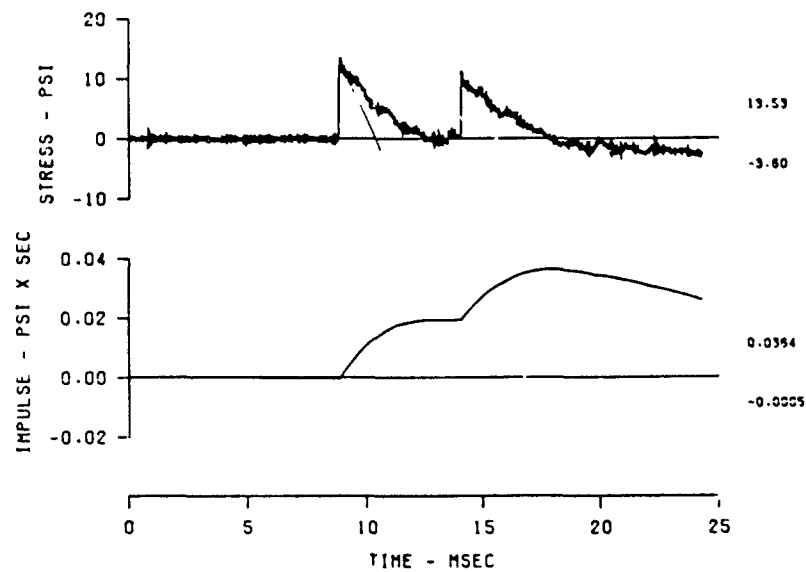
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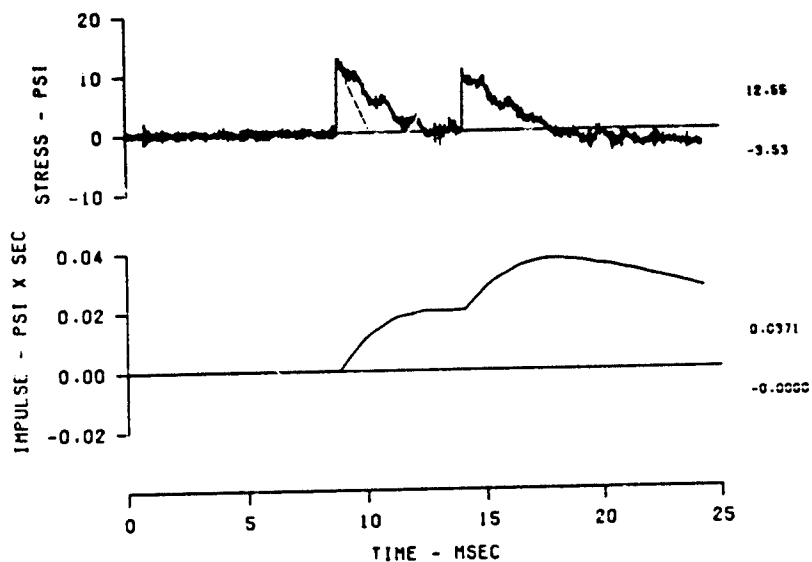
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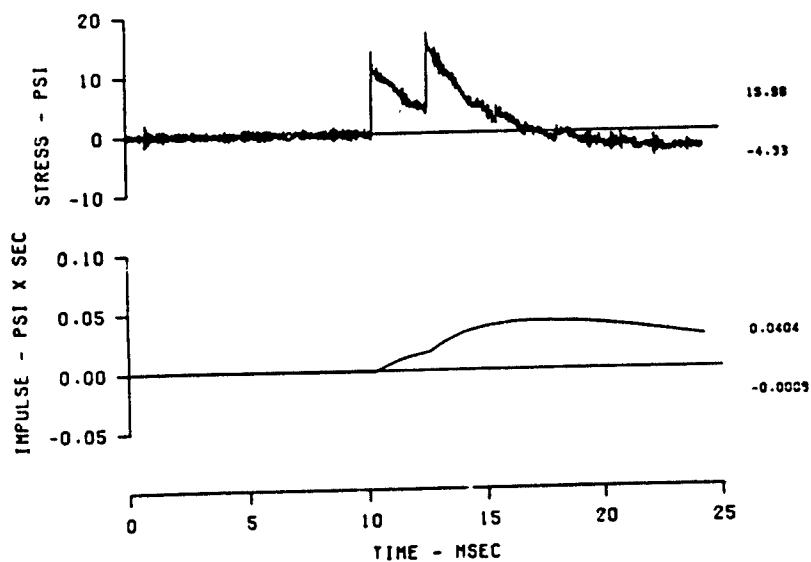
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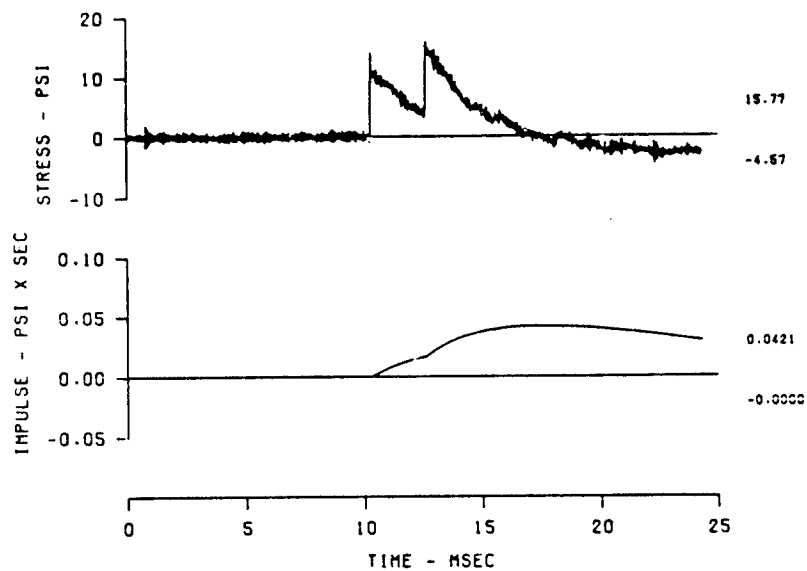
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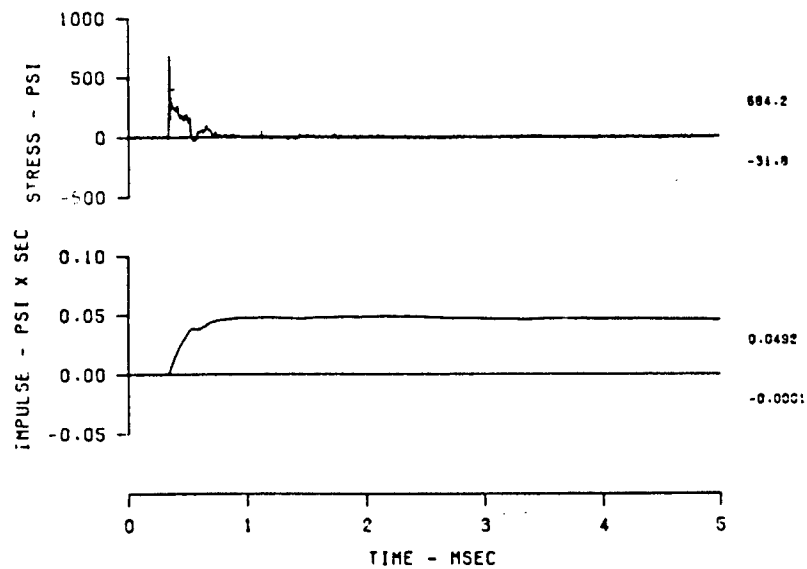
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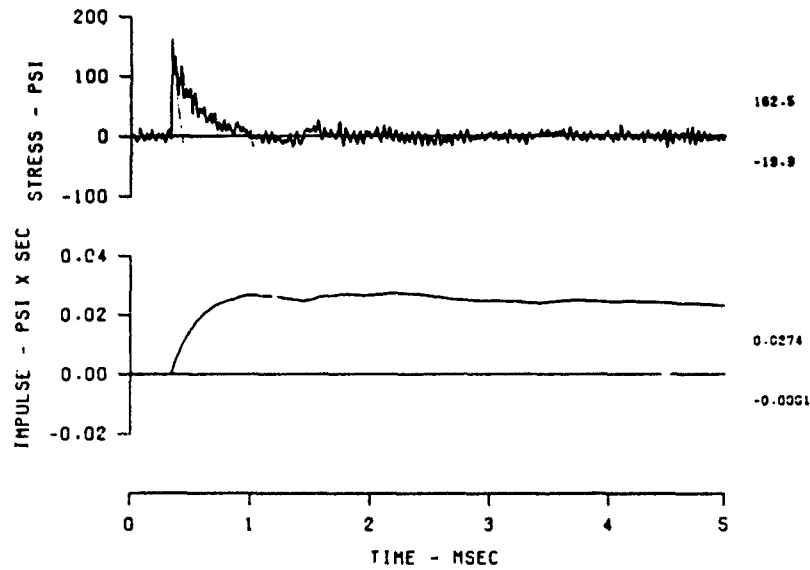
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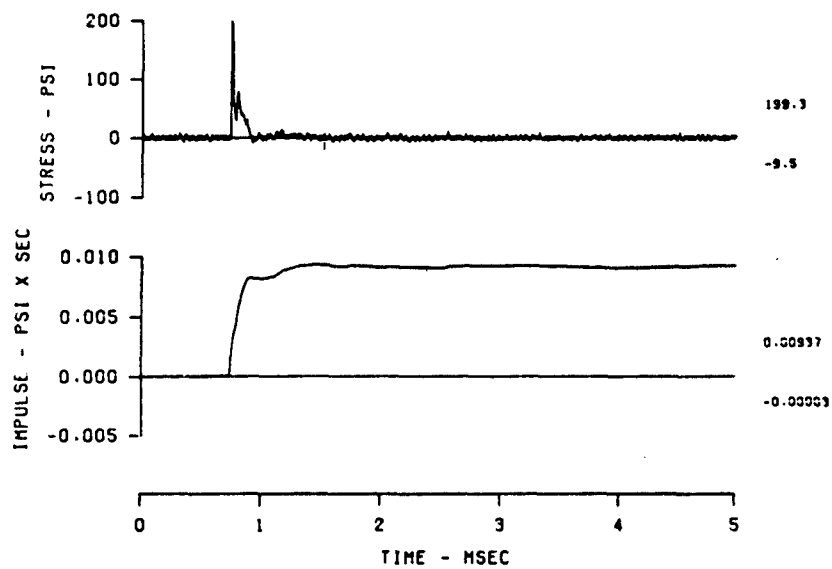
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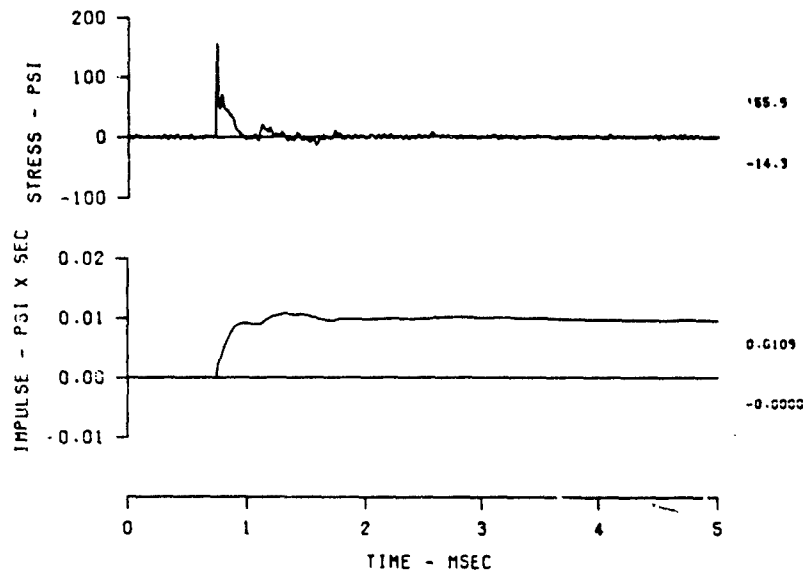
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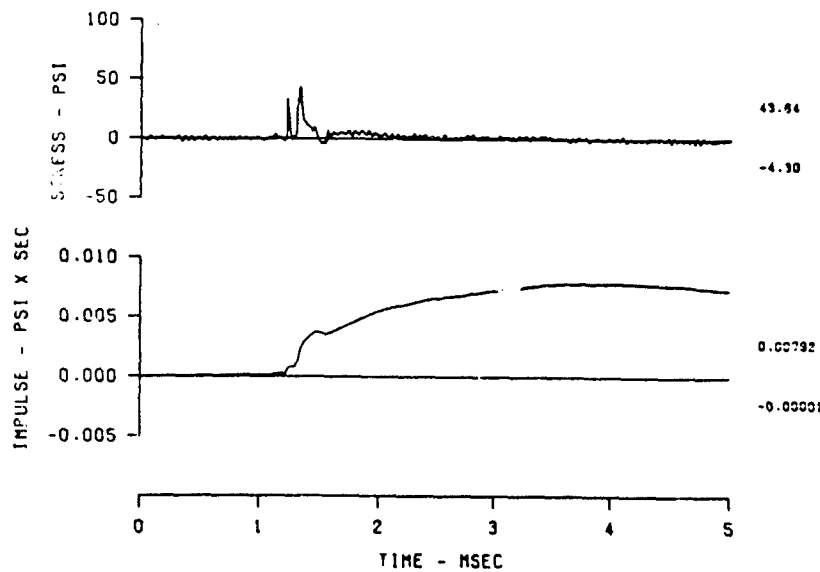
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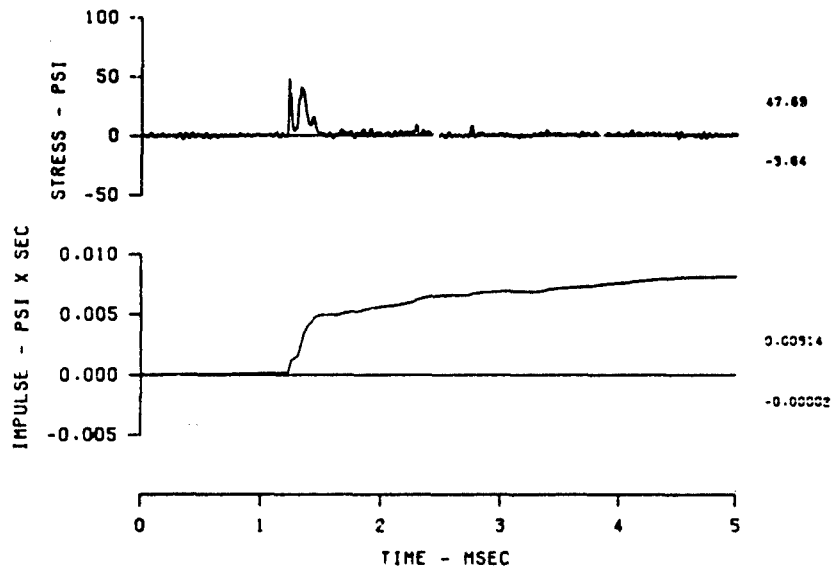
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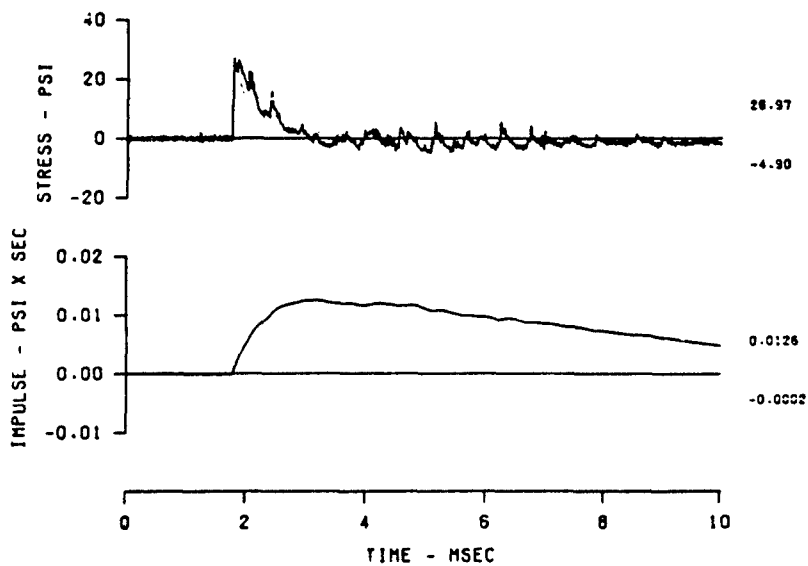
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 AIRBLAST PENETRATION 1983 6 IN TO 1
 500000.HZ 02/27/84



SHOT 20 CH 7 6
AIRBLAST PENETRATION 1983 6 IN TO 1
500000.HZ 02/27/84

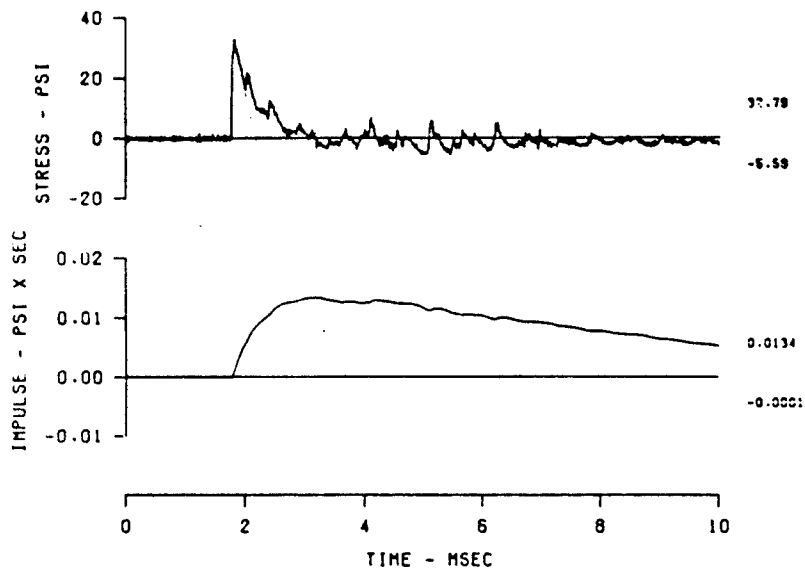


SHOT 20 CH 10 7
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500000.HZ 02/27/84

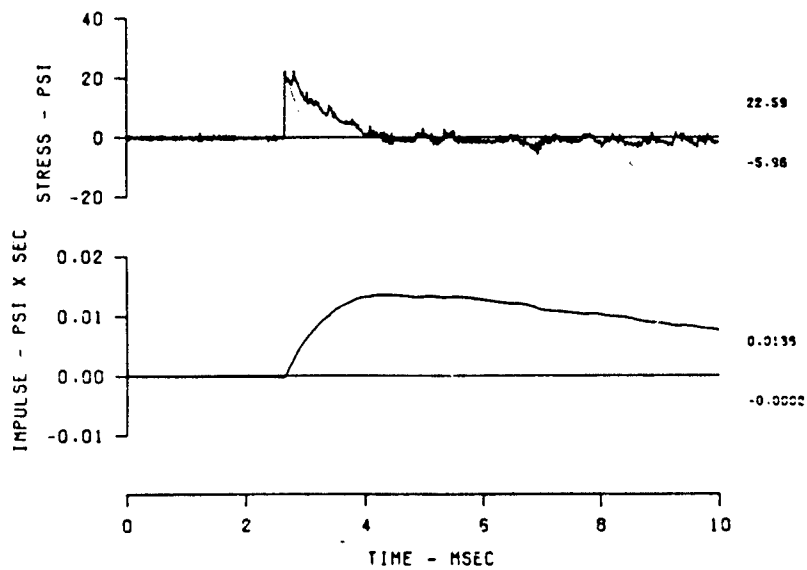


A162

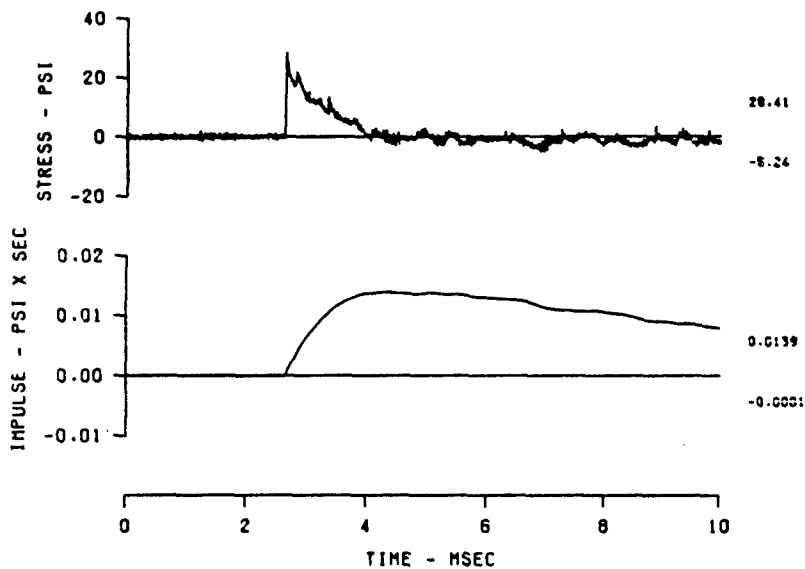
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 500000.HZ 02/27/84



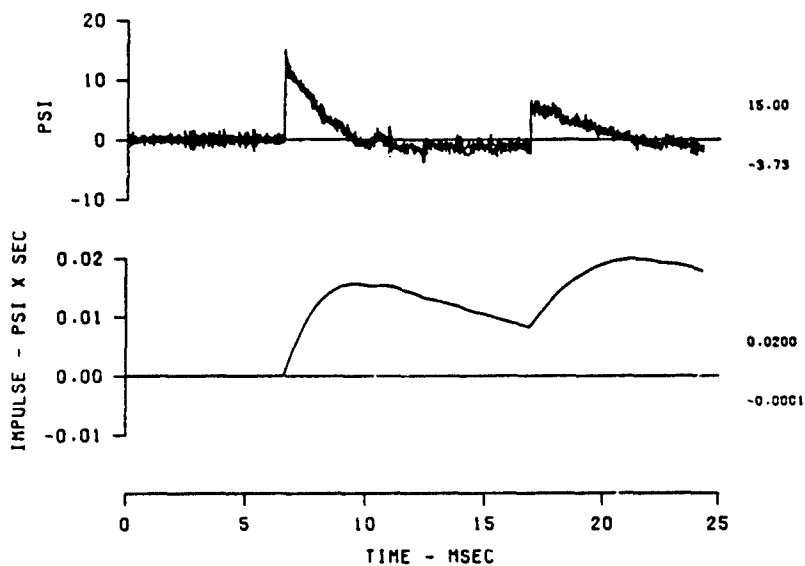
SHOT 20 CH 12 9
 AIRBLAST PENETRATION 1983 6 IN TO 1
 500000.HZ 02/27/84



SHOT 20 CH 13 10
 AIRBLAST PENETRATION 1983 6 IN TO 1
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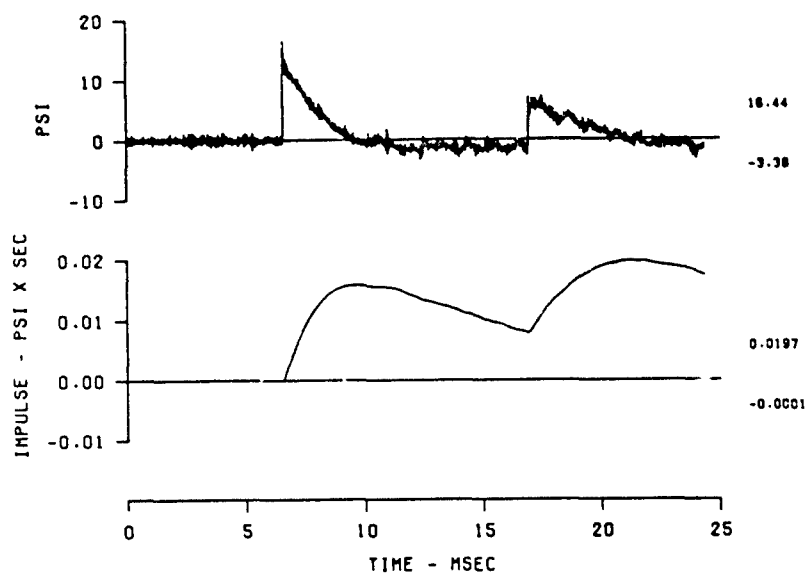
SHOT 20 CH 14 11
 AIRBLAST PENETRATION 1983 6 IN TO 12 IN
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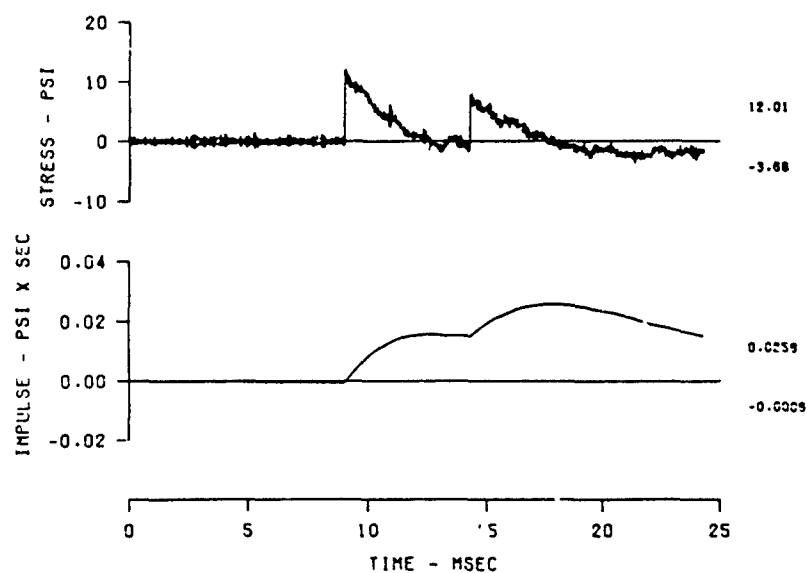
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SHOT 20 CH 15 12
AIRBLAST PENETRATION 1983 6 IN TO 12 IN
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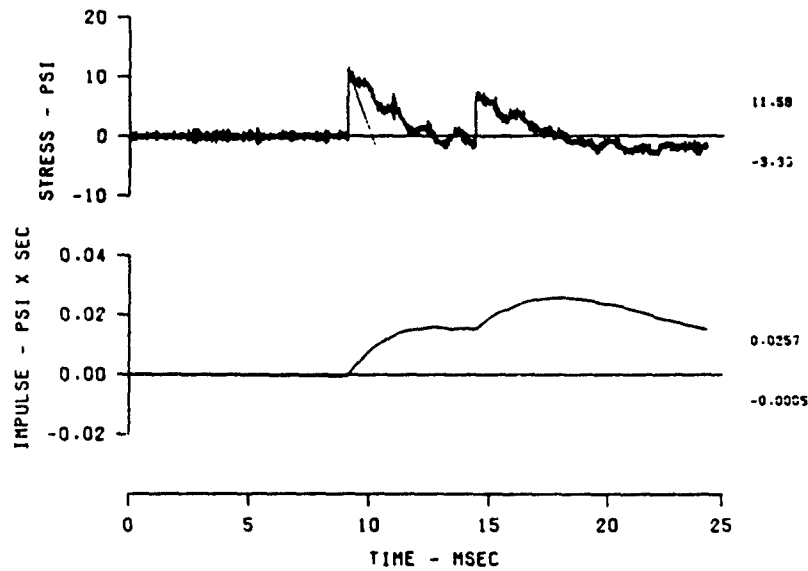


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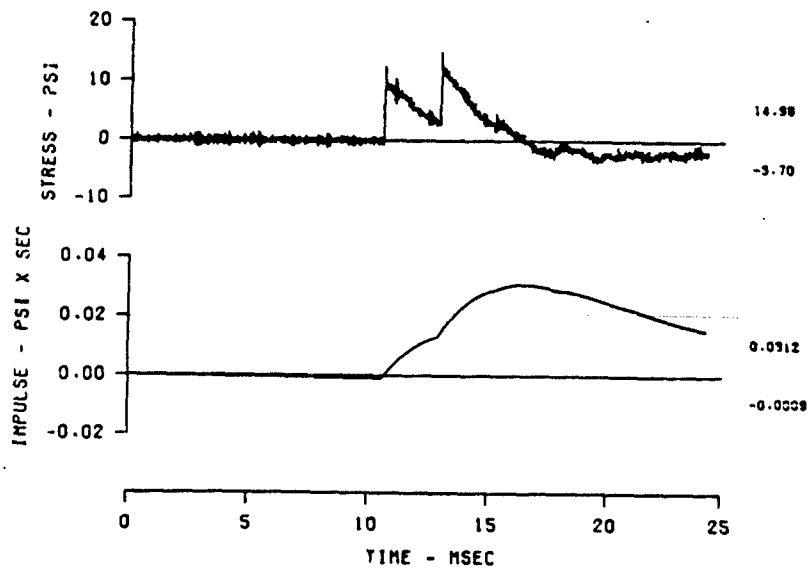


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500000.HZ 02/27/84

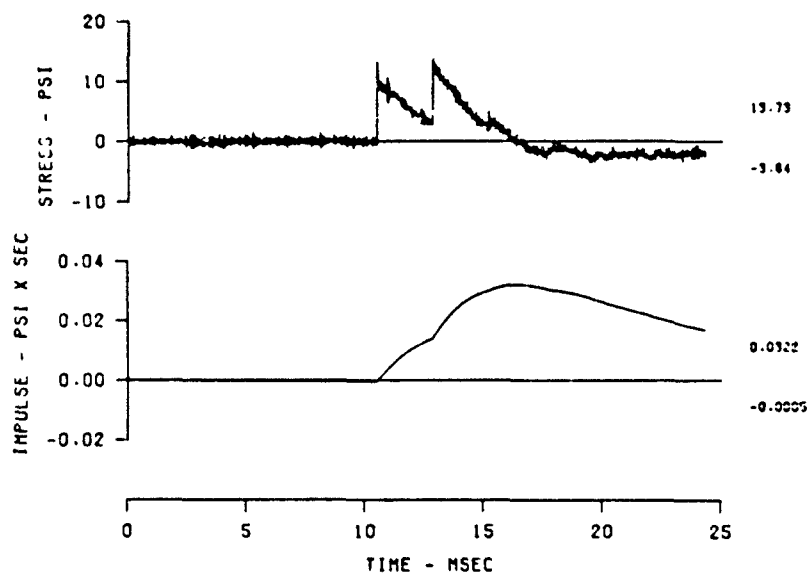


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500000.HZ 02/27/84

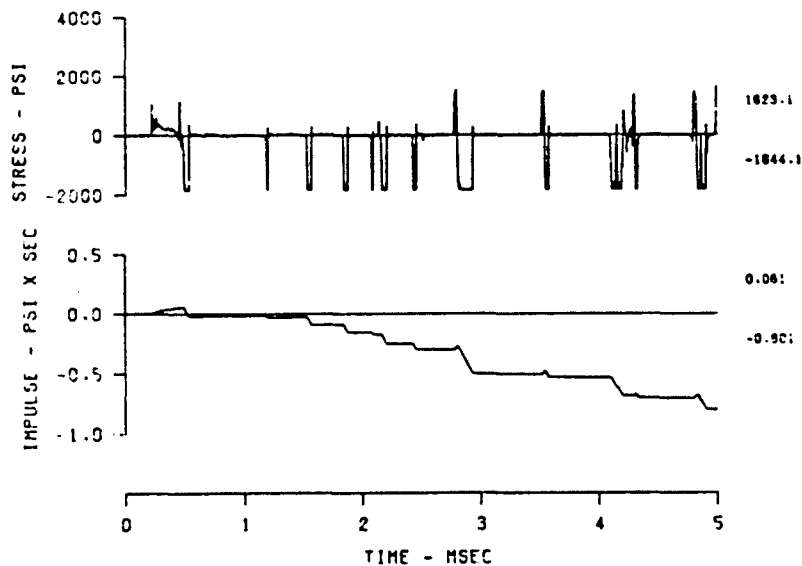


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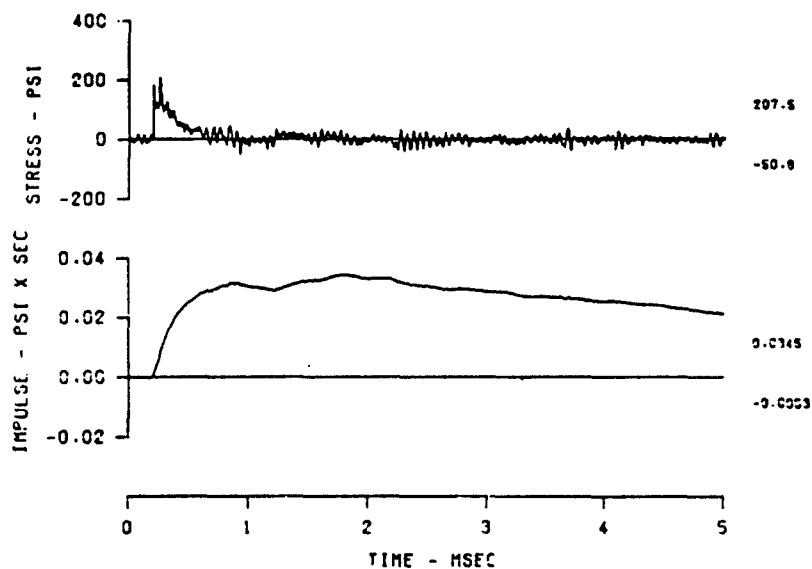
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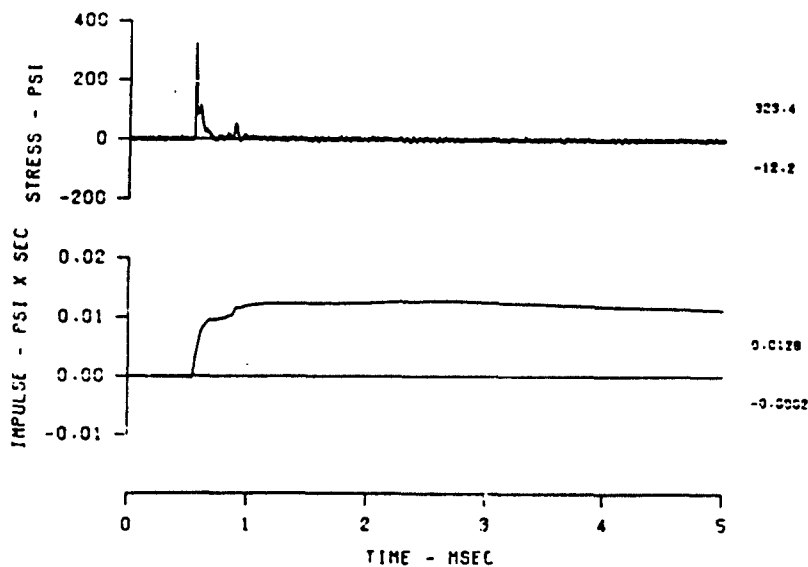
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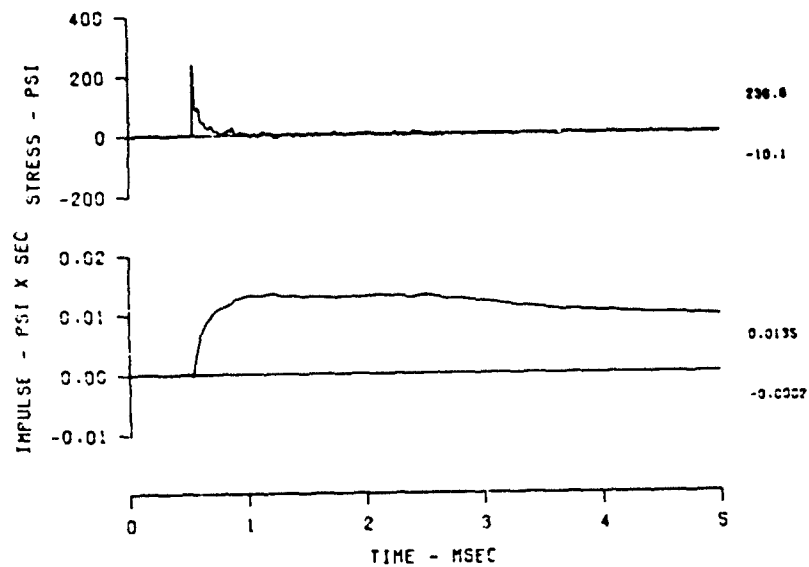
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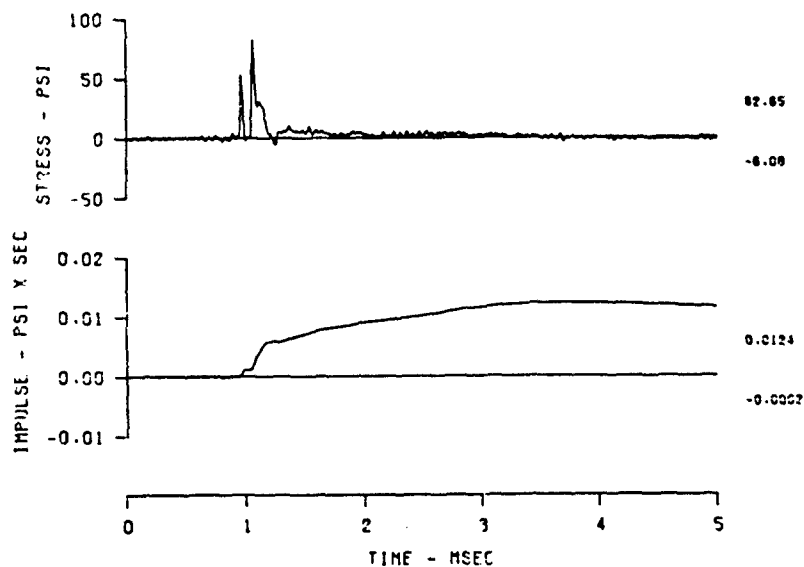
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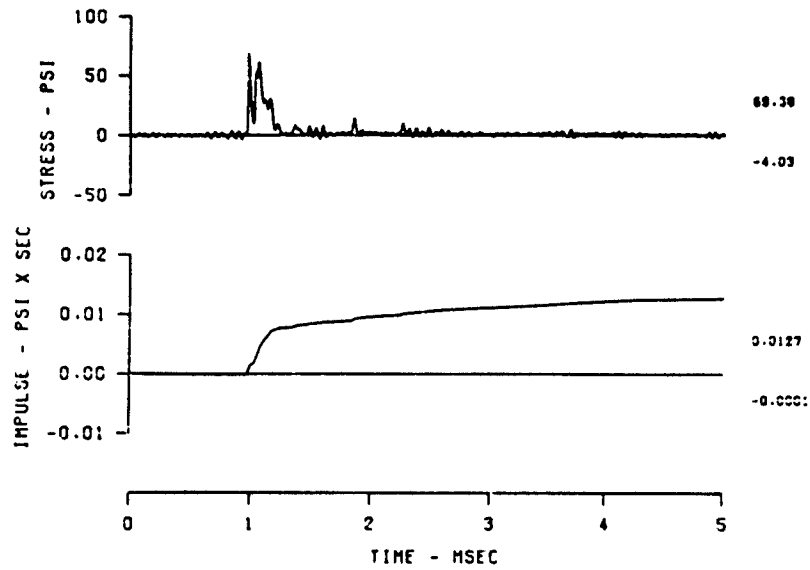
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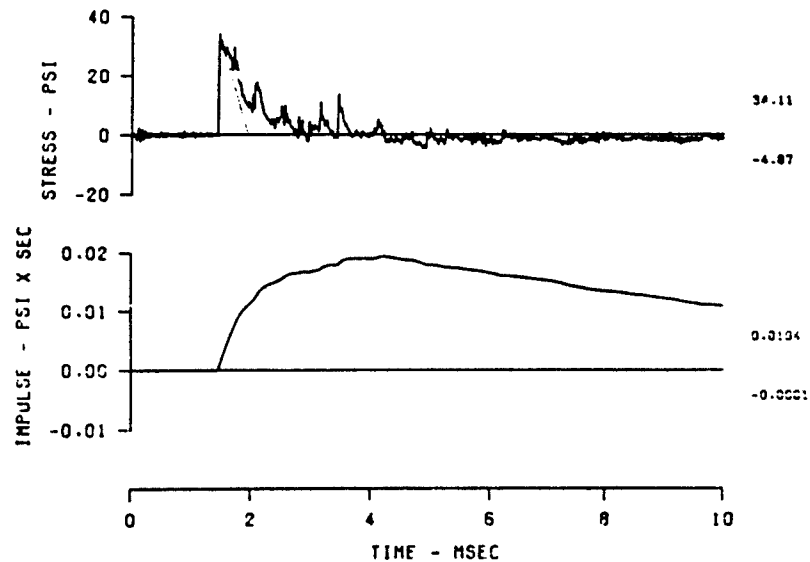
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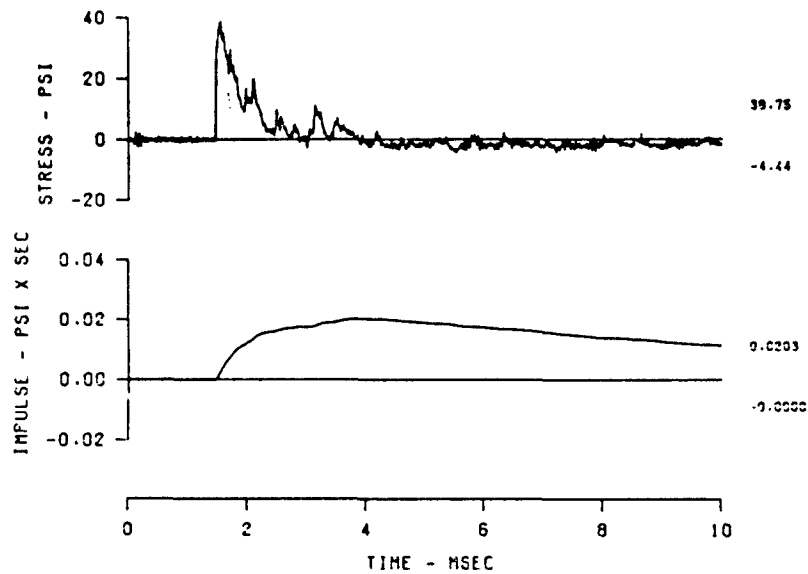
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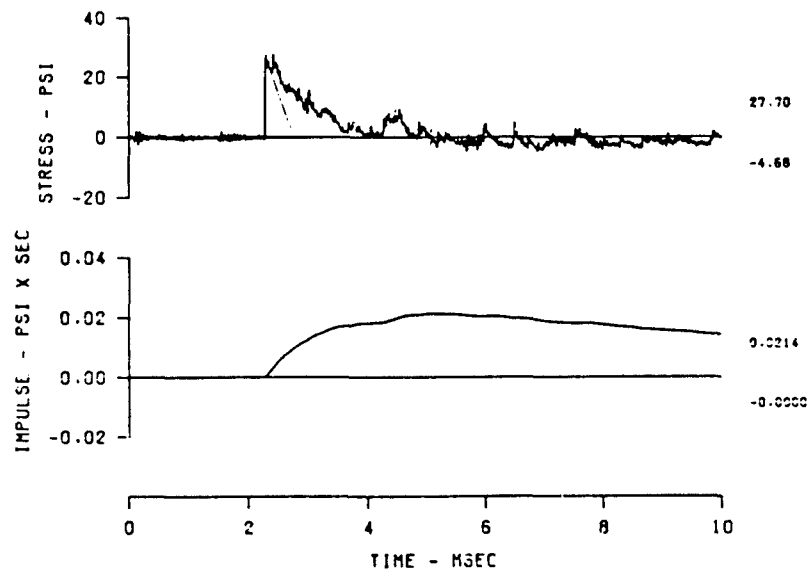
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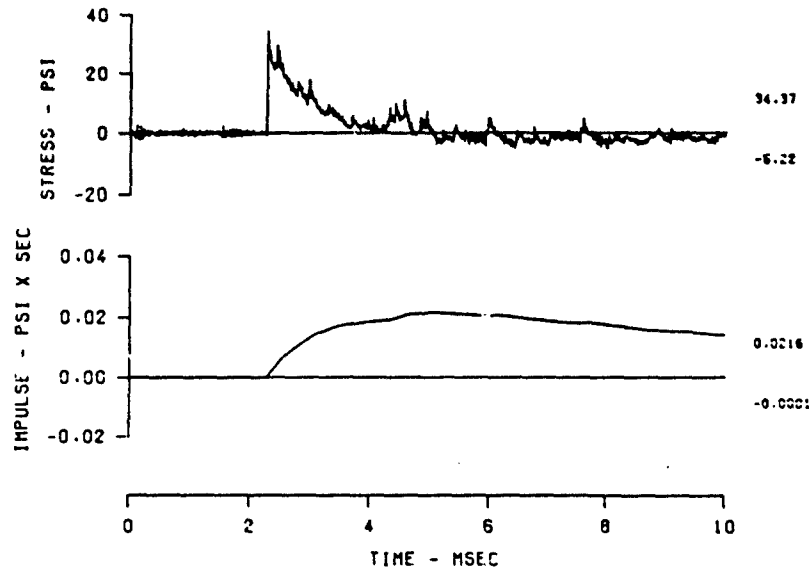
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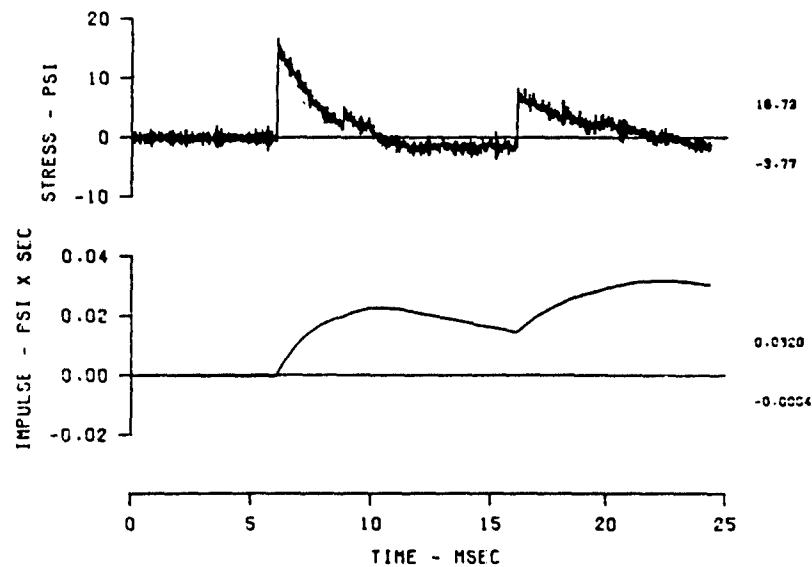
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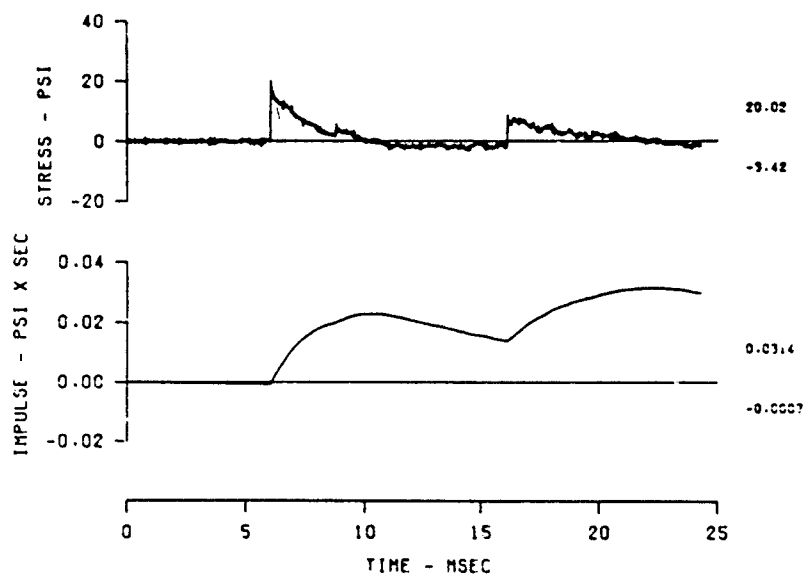
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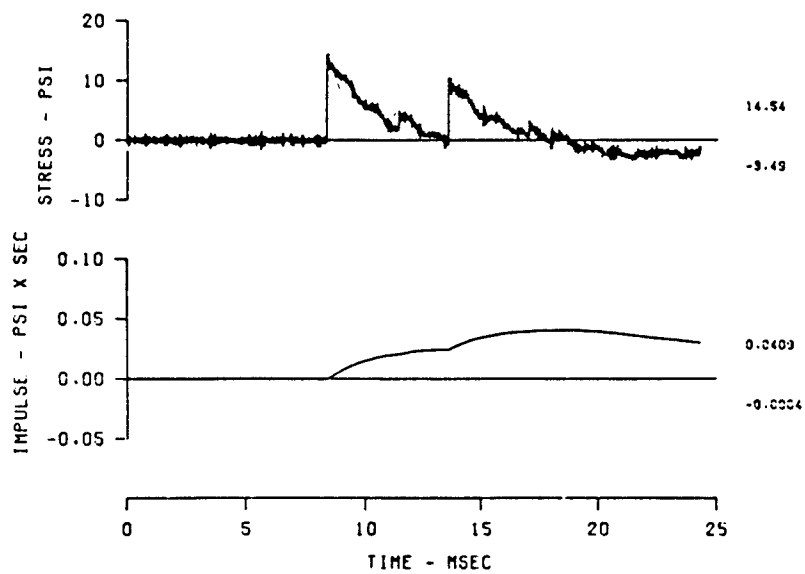
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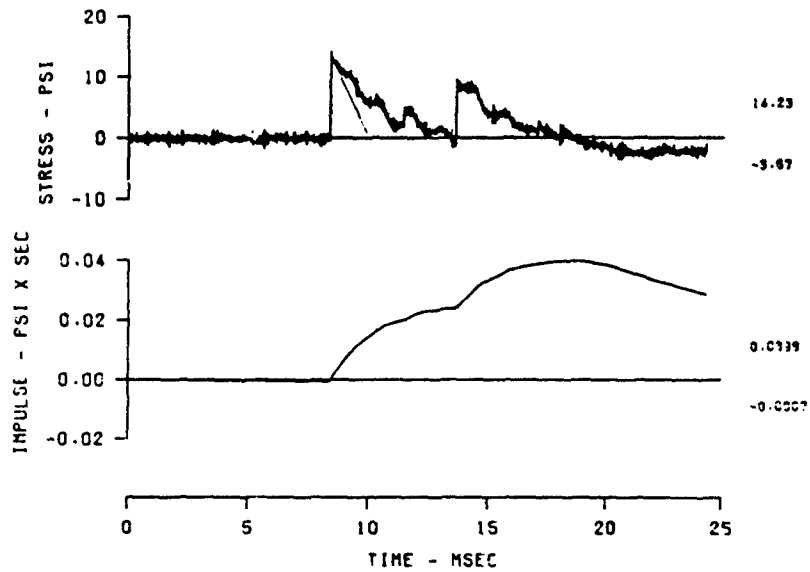
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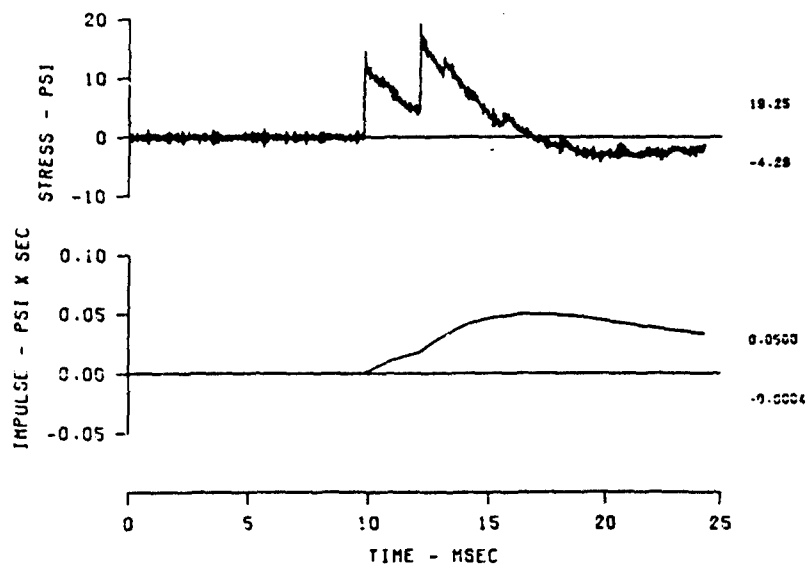
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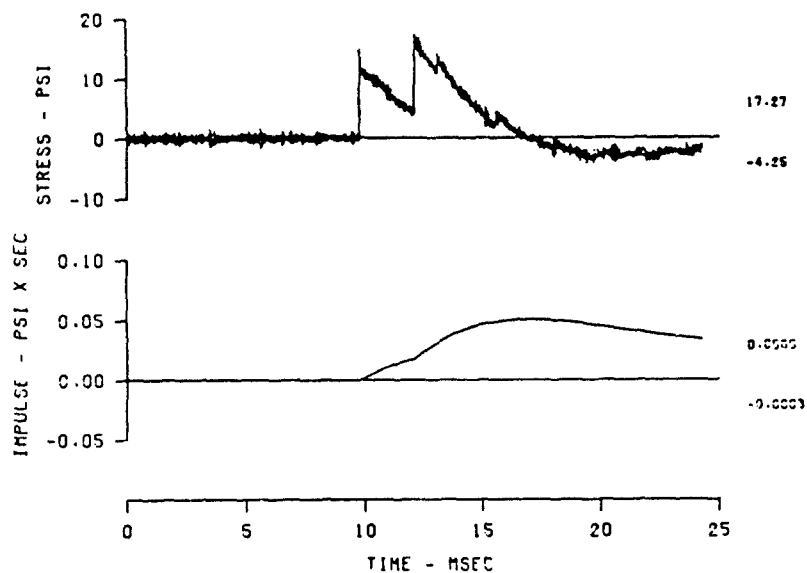
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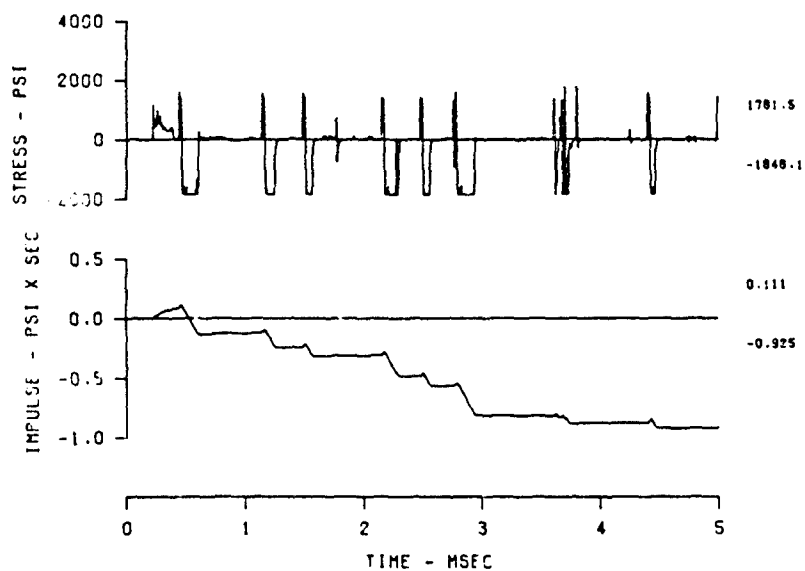
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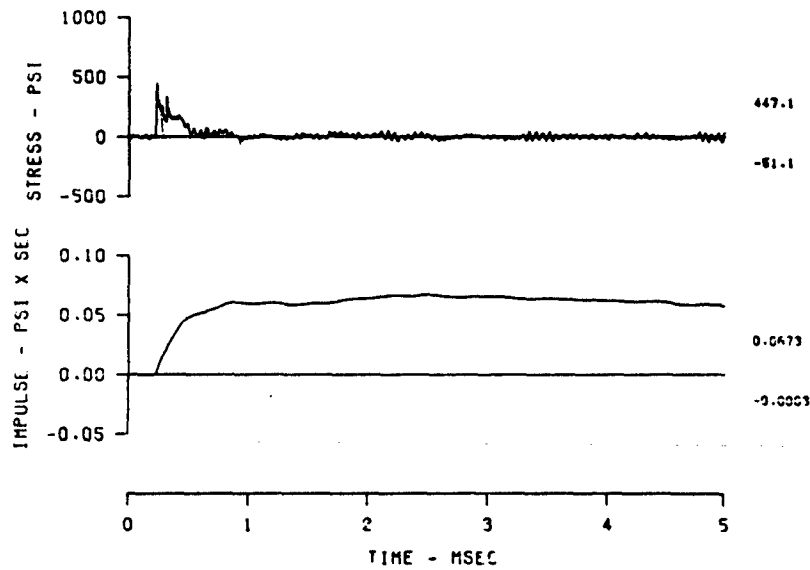
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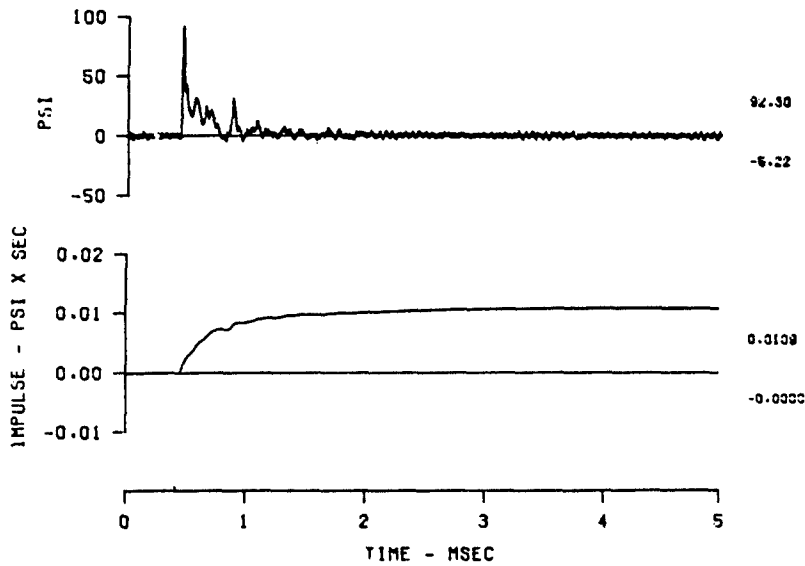
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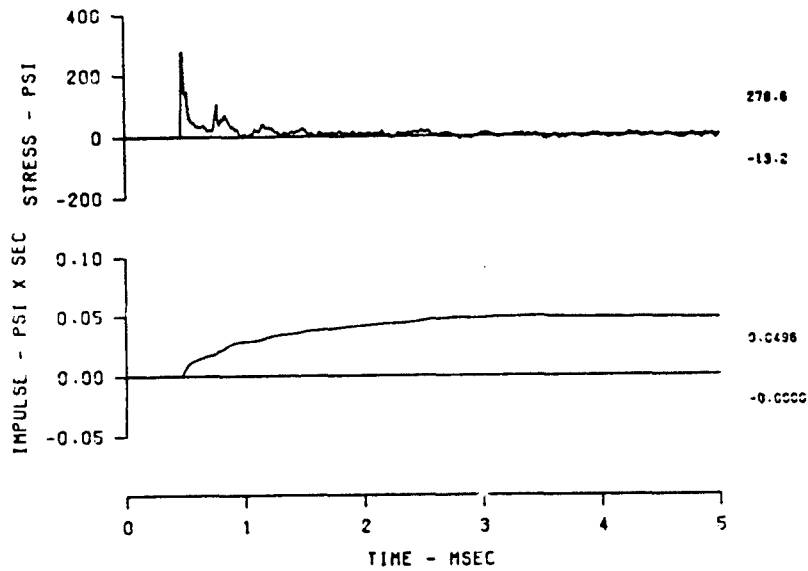
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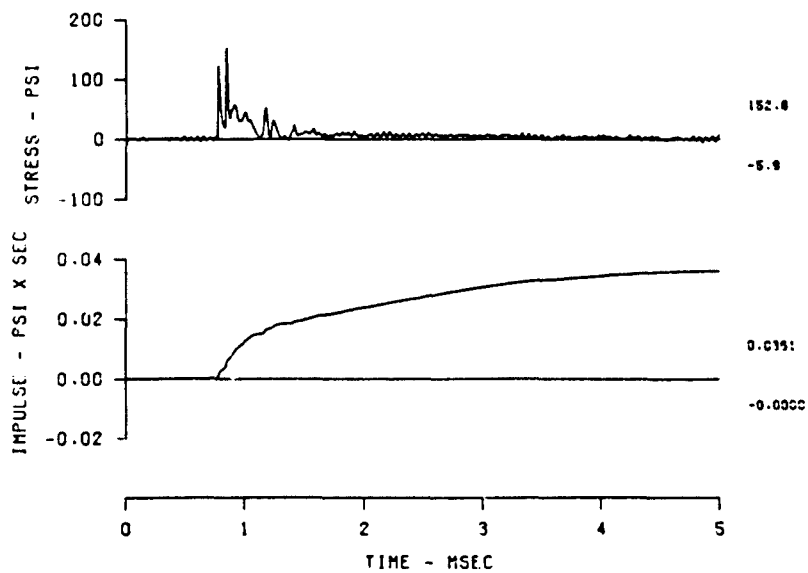
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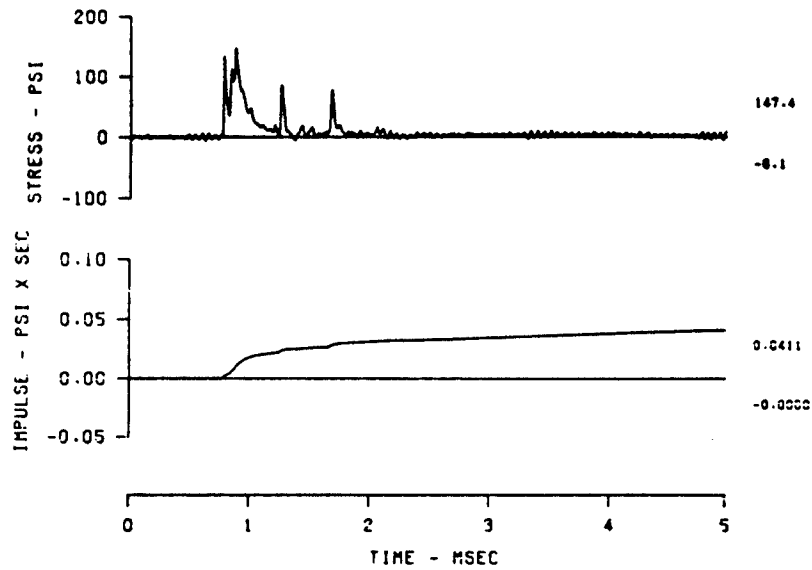
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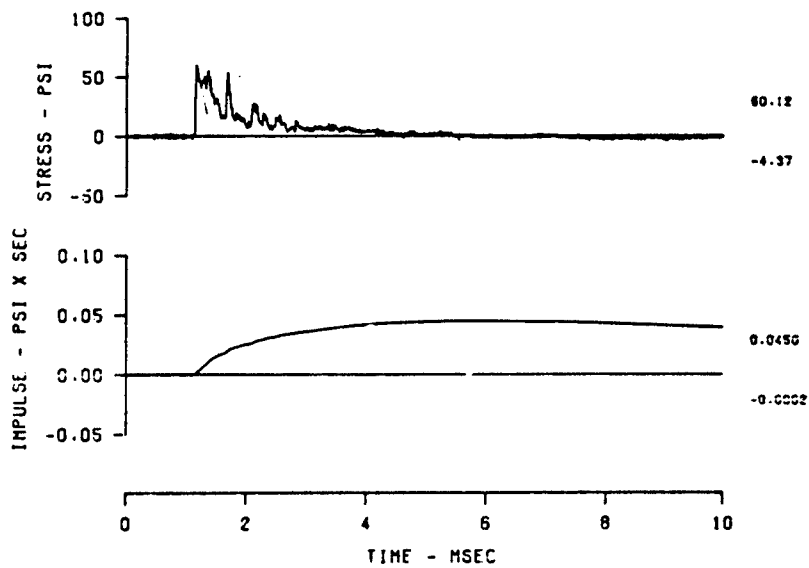
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500000.HZ 02/27/84



SHOT 22 CH 7 6
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 500000.HZ 02/27/84

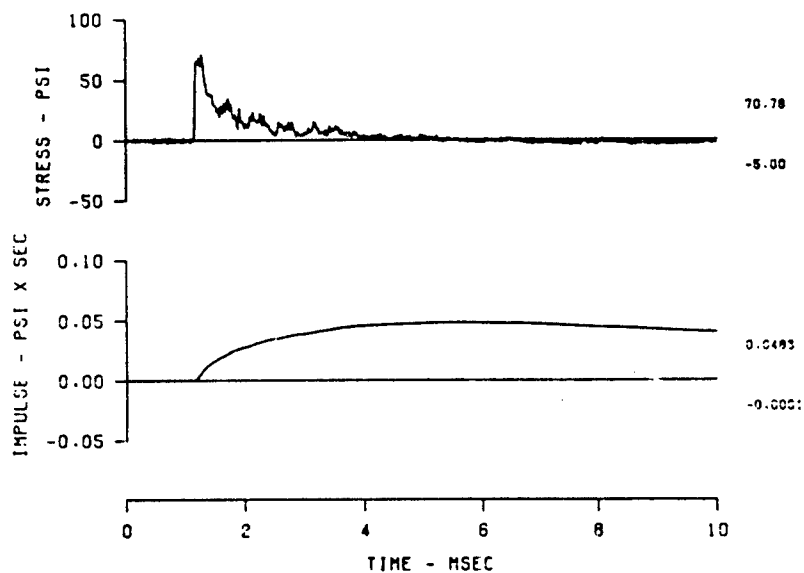


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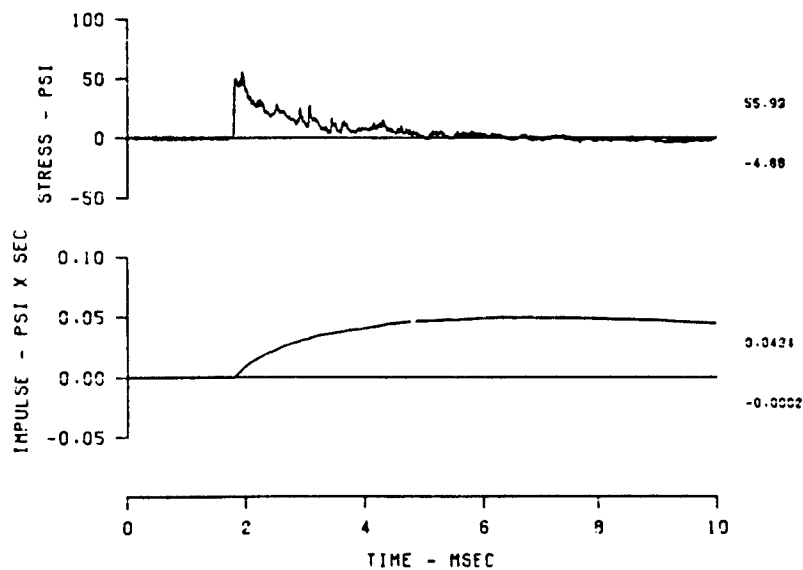


A178

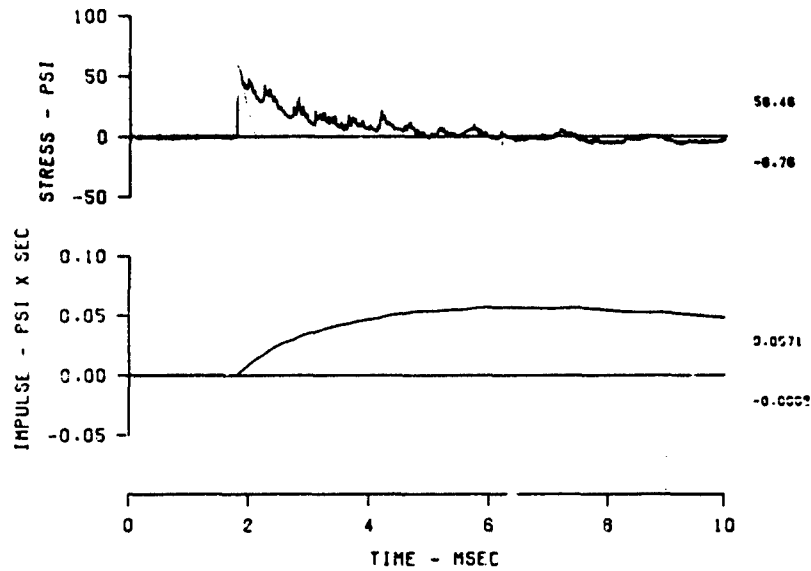
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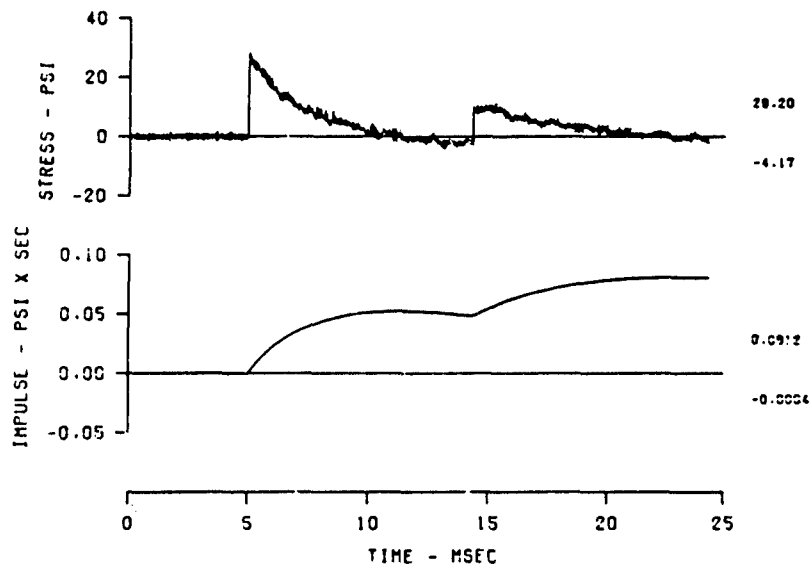
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500000.HZ 02/27/84



SHOT 22 CH 13 10
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 500000.HZ 02/27/84

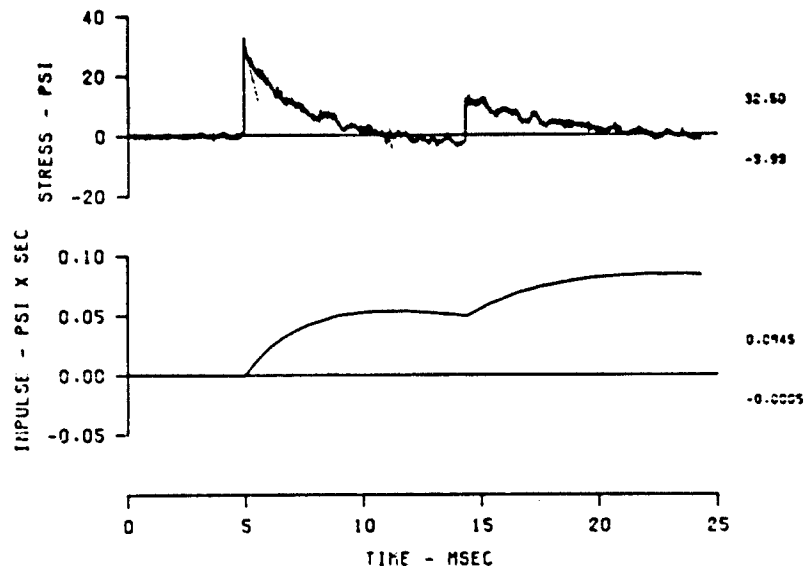


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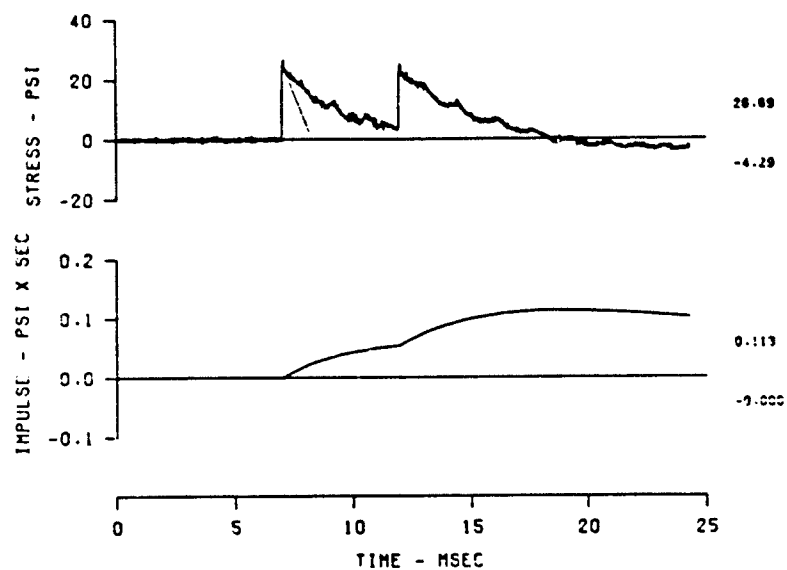


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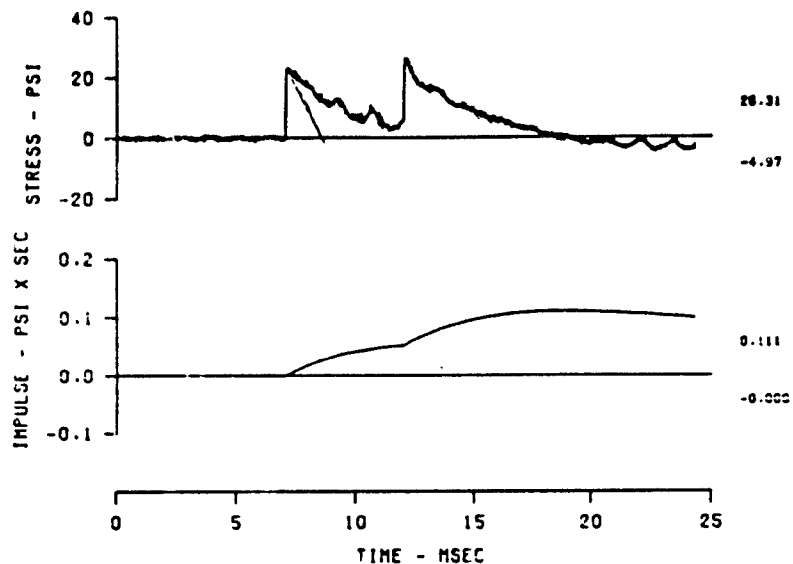
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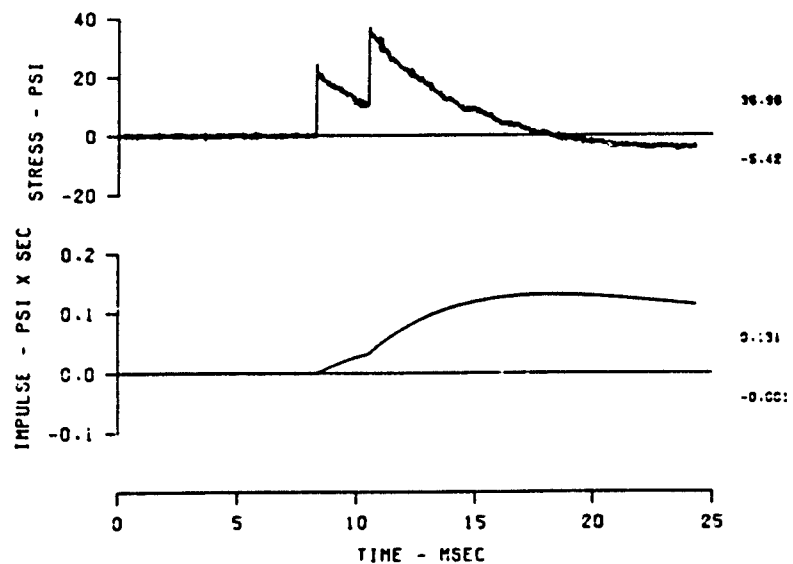
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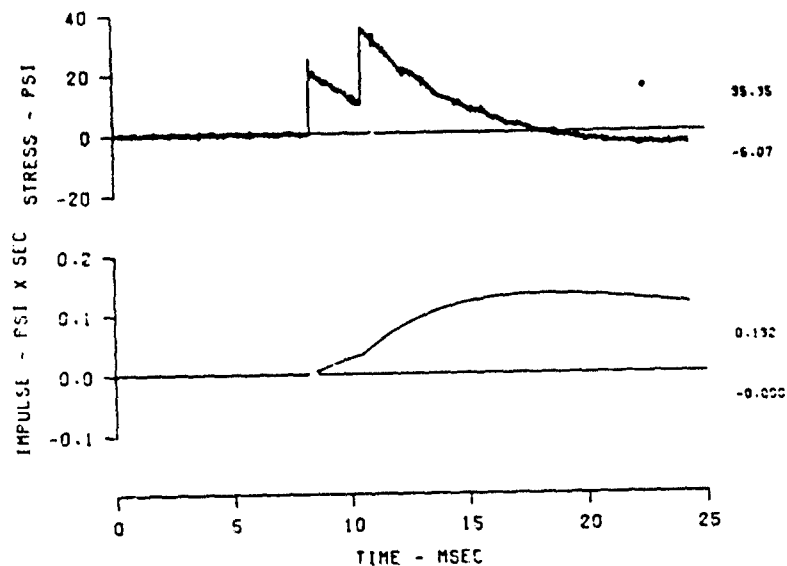
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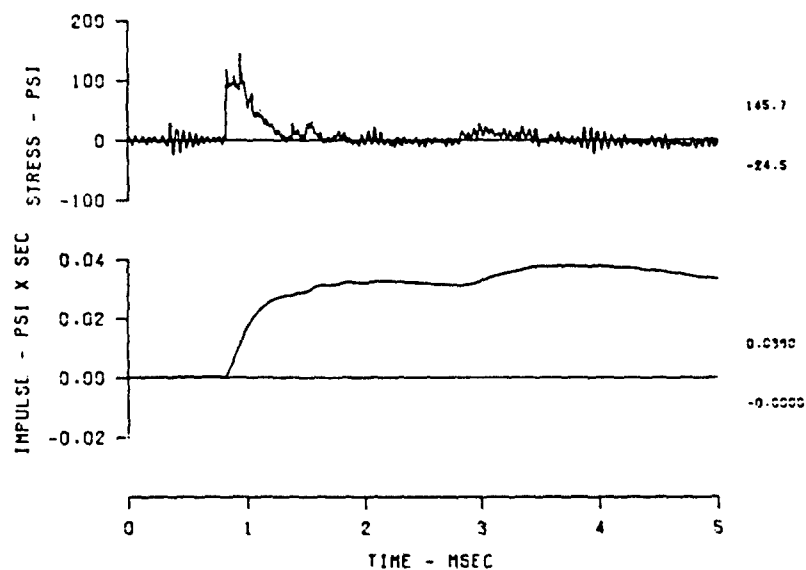
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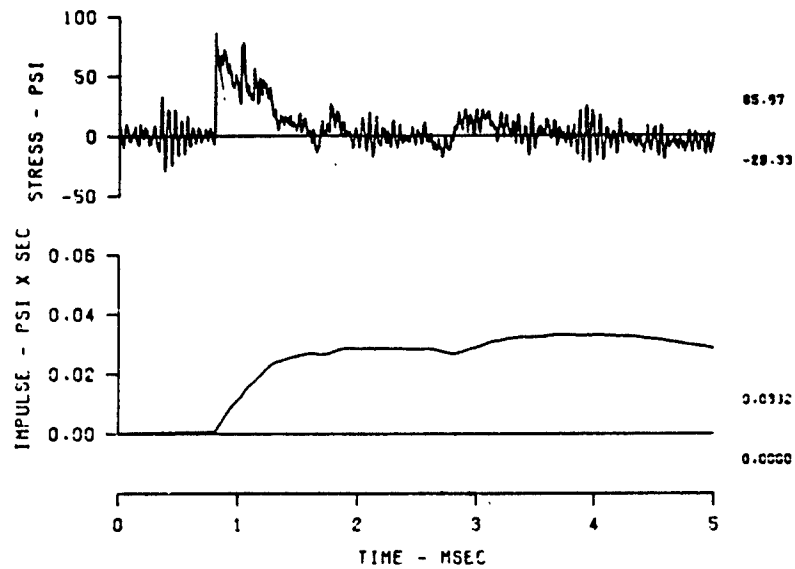
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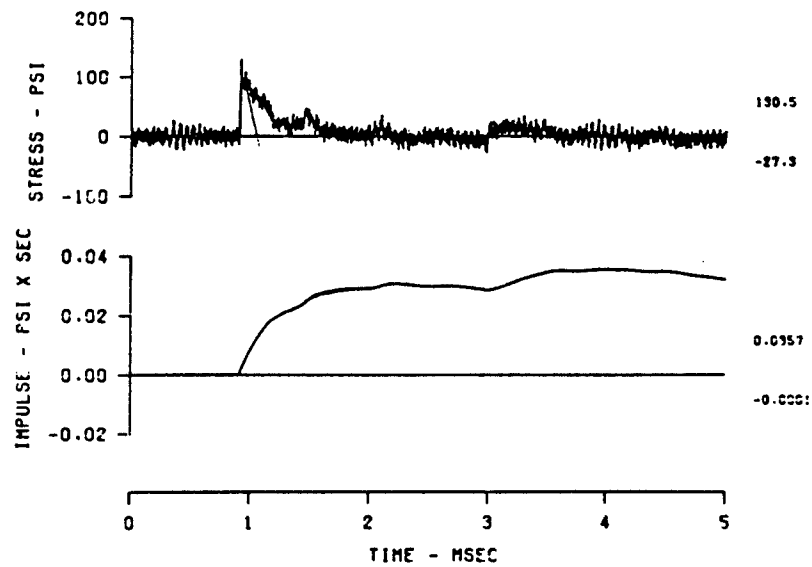
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 500000.HZ 02/27/84



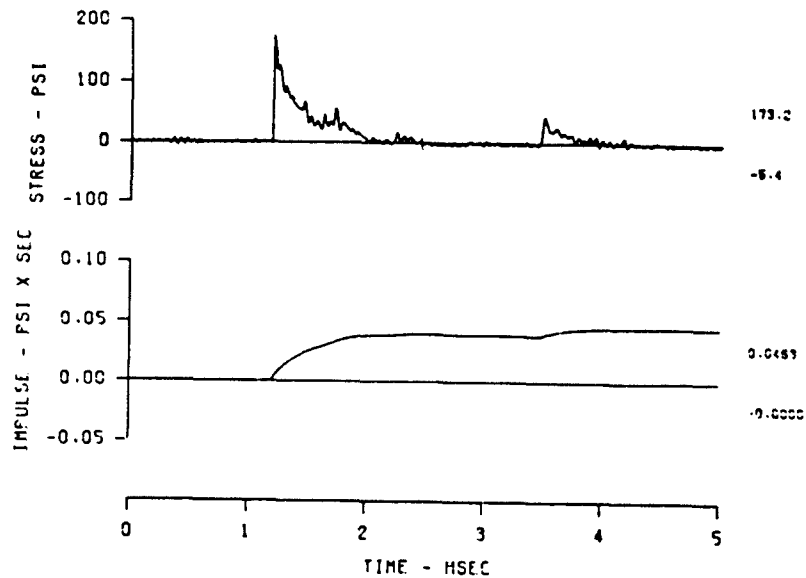
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500000.HZ 02/27/84



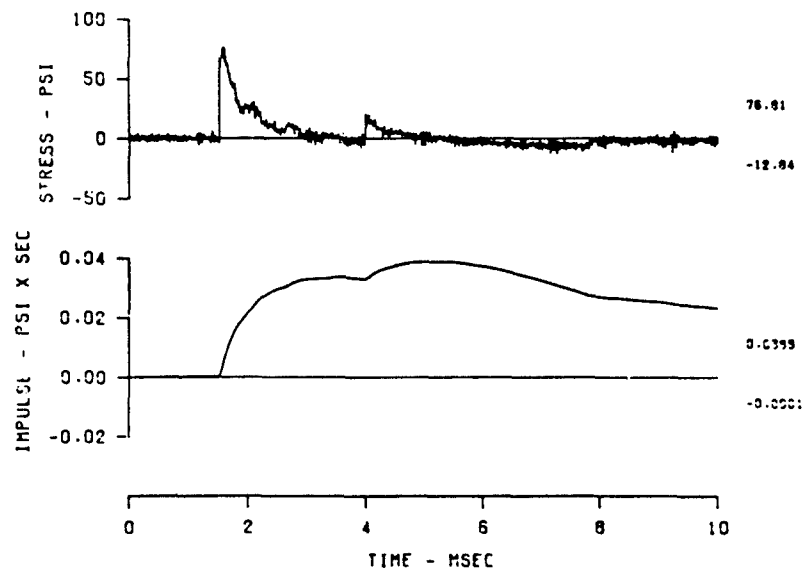
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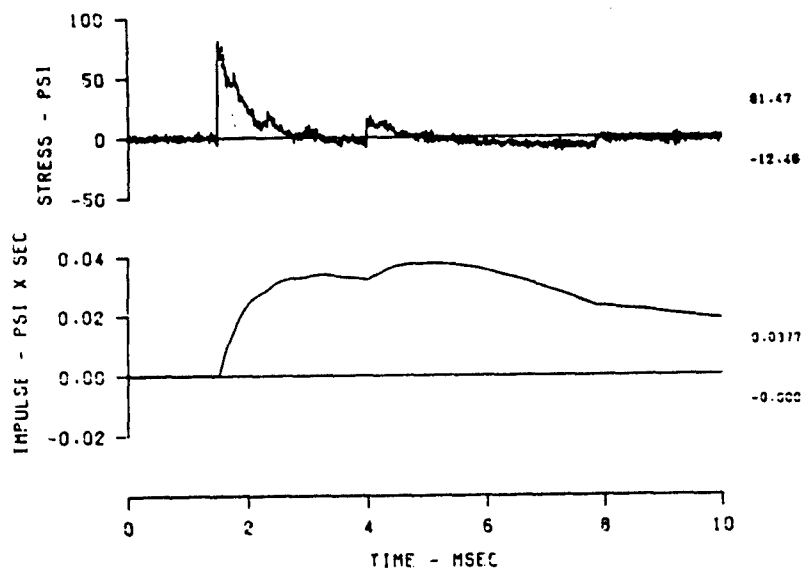
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 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



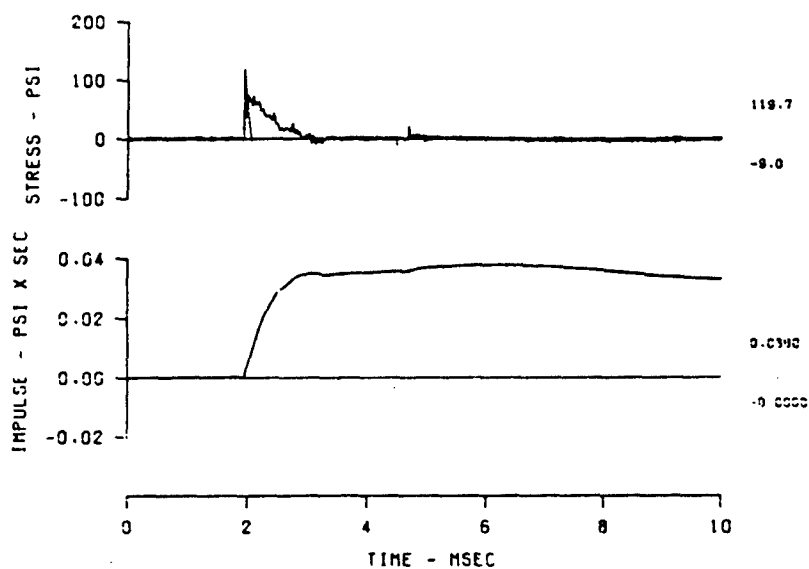
SHOT 23 CH 8 7
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



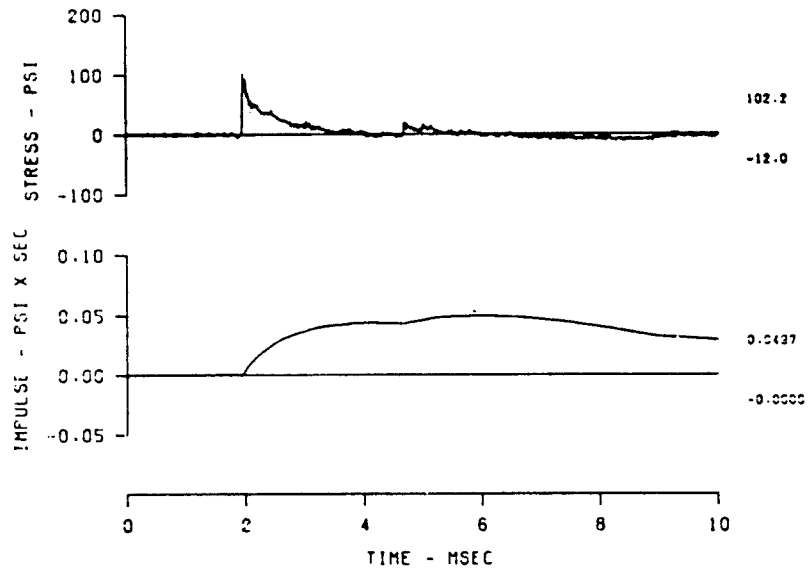
SHOT 23 CH 9 8
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



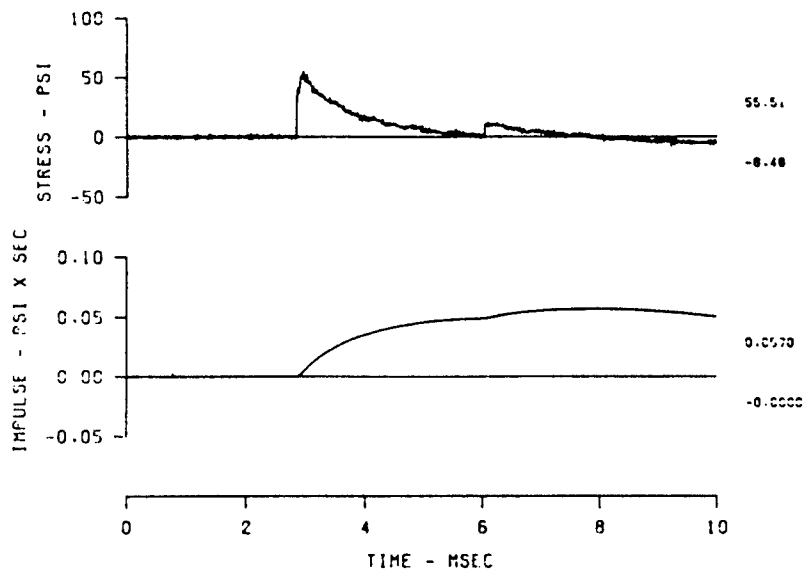
SHOT 23 CH 10 9
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



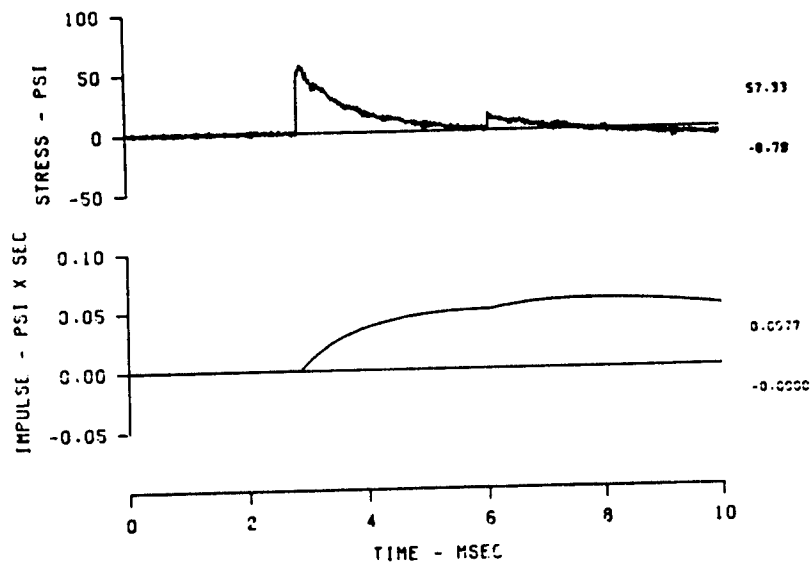
SHOT 23 CH 11 10
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



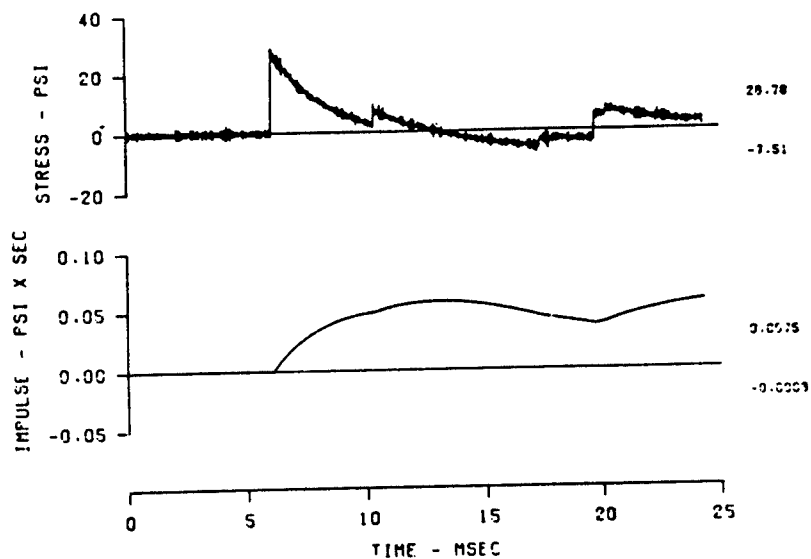
SHOT 23 CH 12 11
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



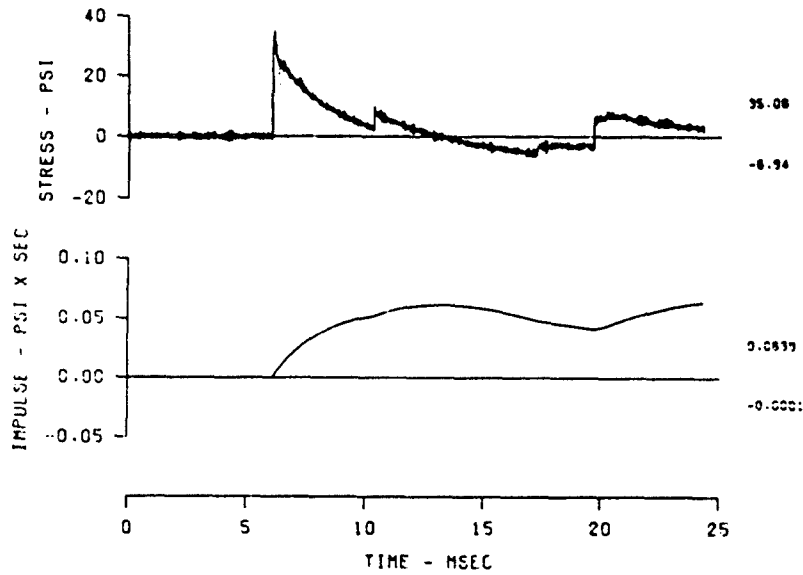
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 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



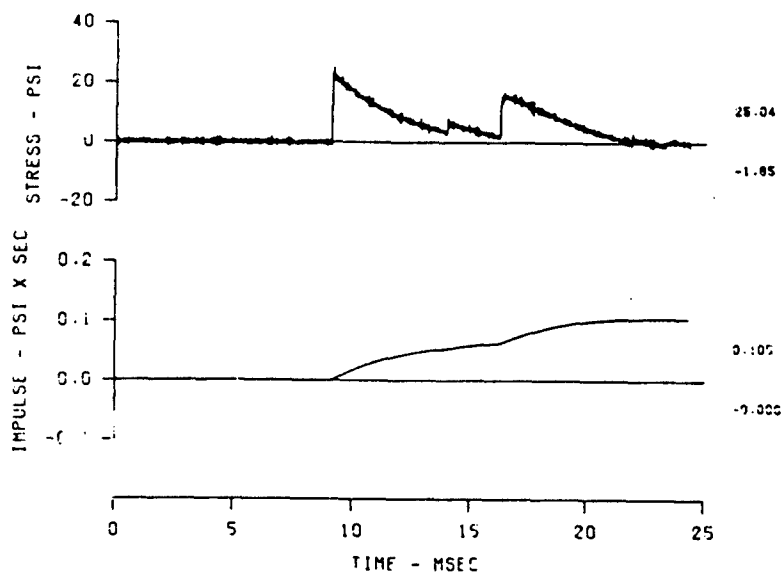
SHOT 23 CH 14 13
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



SHOT 23 CH 15 14
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 500000.HZ 02/27/84

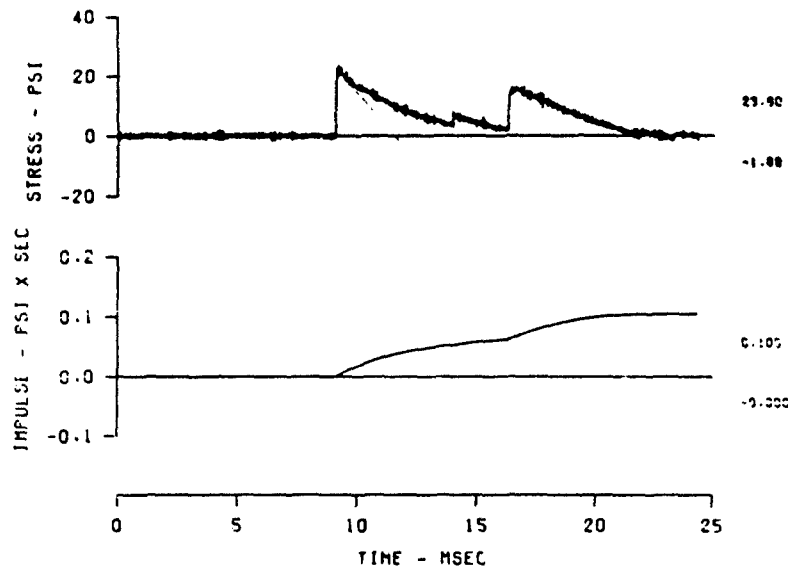


SHOT 23 CH 15 15
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 500000.HZ 02/27/84

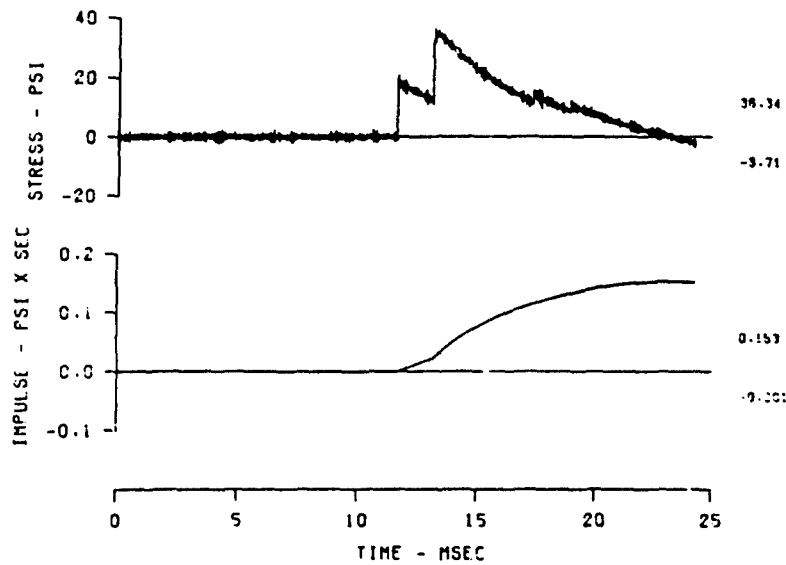


AL89

SHOT 23 CH 17 16
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

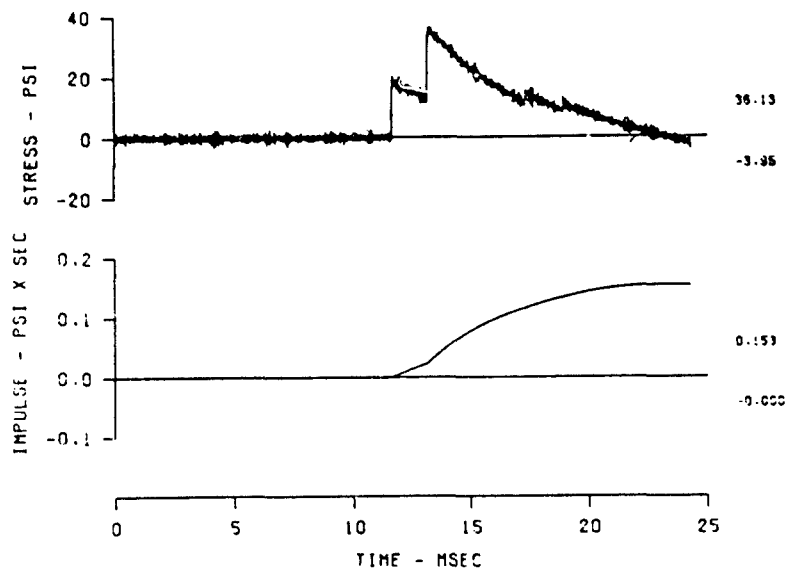


SHOT 23 CH 18 17
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

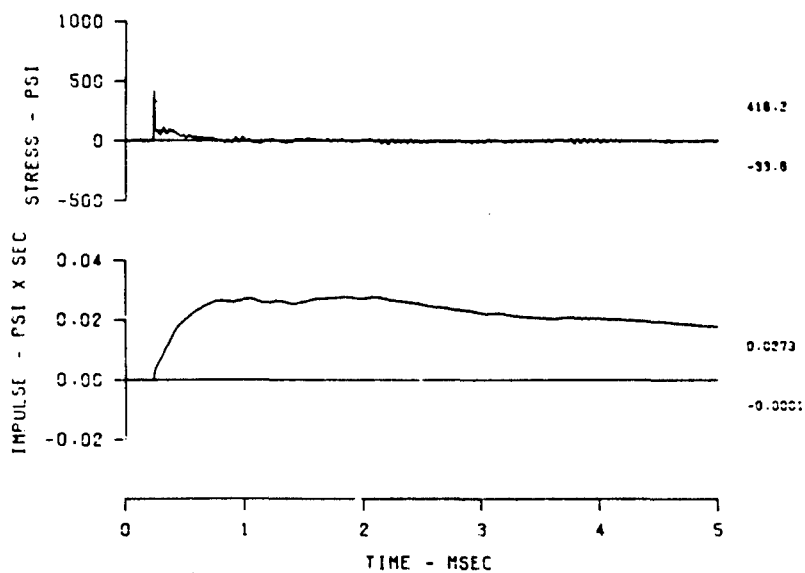


A190

SHOT 23 CH 13 18
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

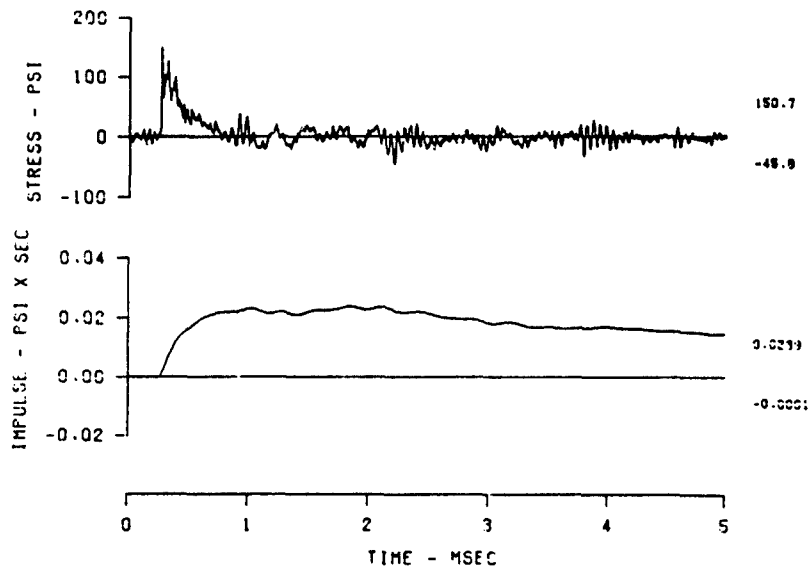


SHOT 24 CH 2 1
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 500000.HZ 02/27/84

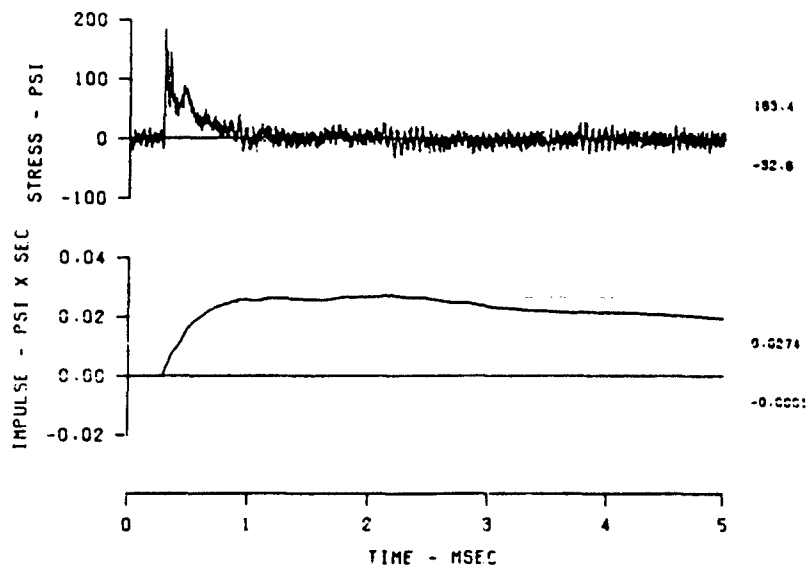


A191

SHOT 24 CH 3 2
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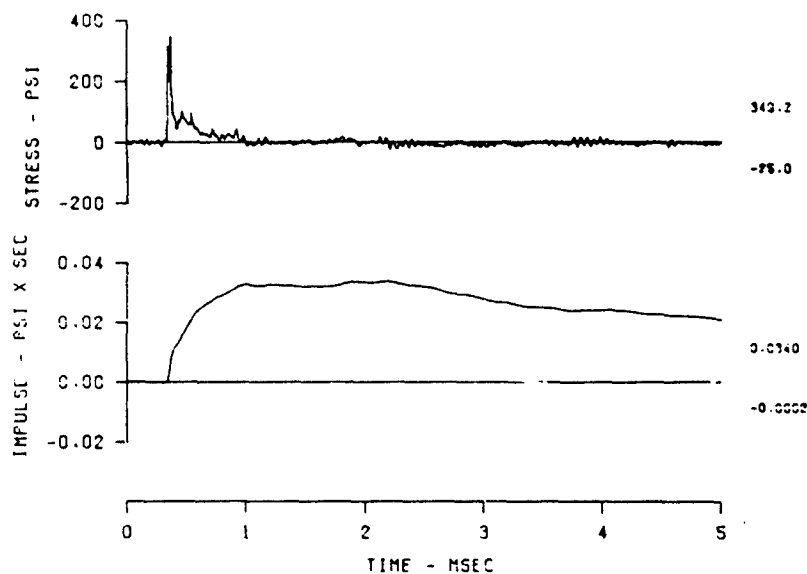


SHOT 24 CH 4 3
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500000.HZ 02/27/84

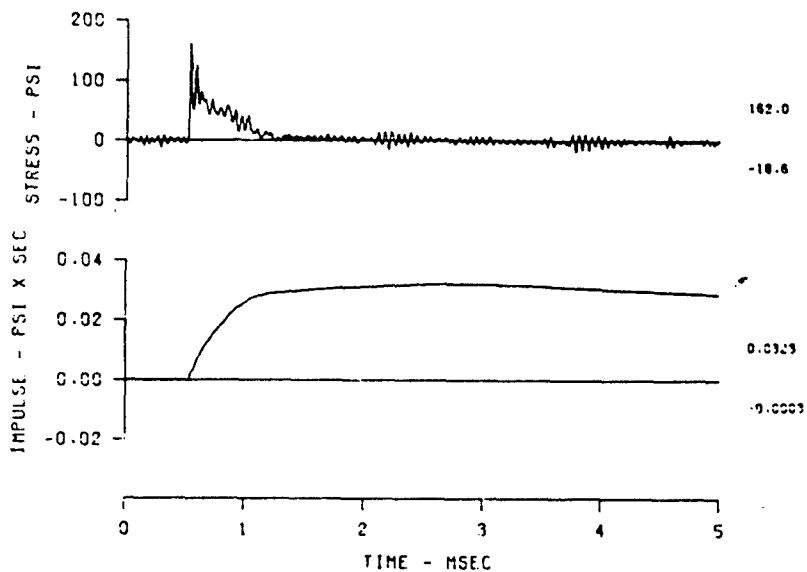


A192

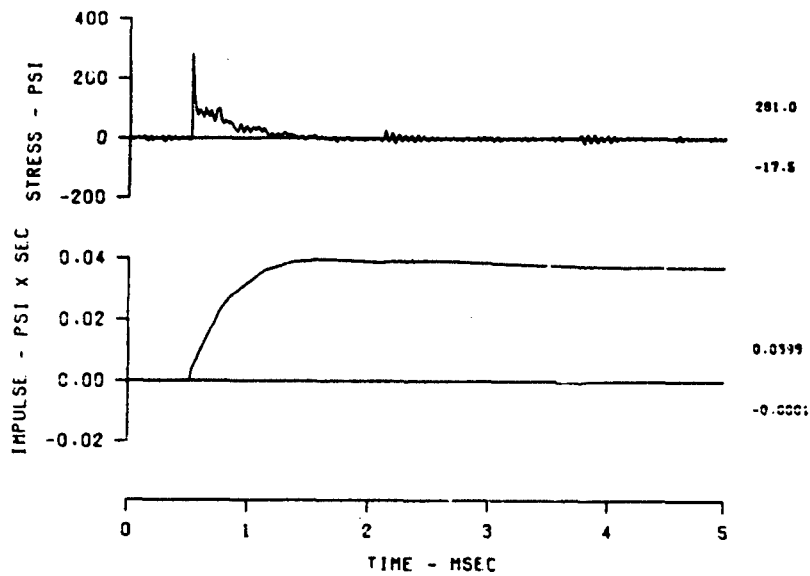
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500000.HZ 02/27/84



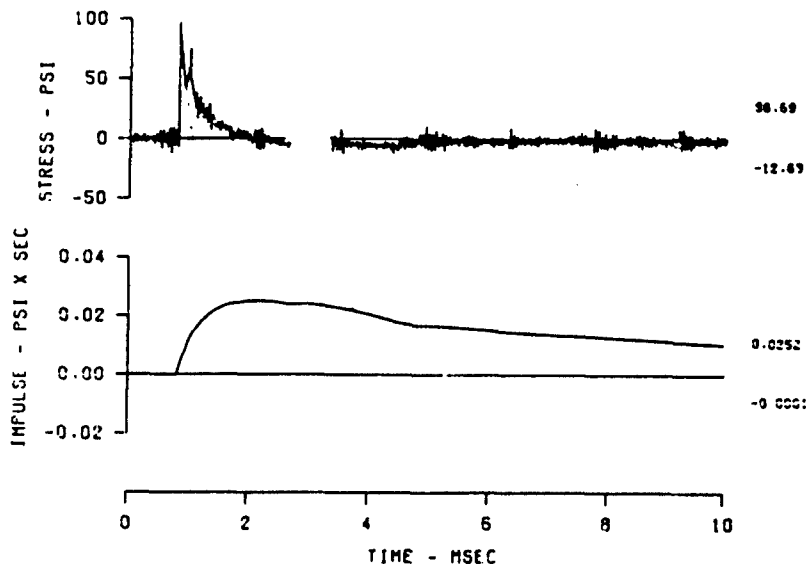
SHOT 24 CH 6 5
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



SHOT 24 CH 7 6
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500000.HZ 02/27/84

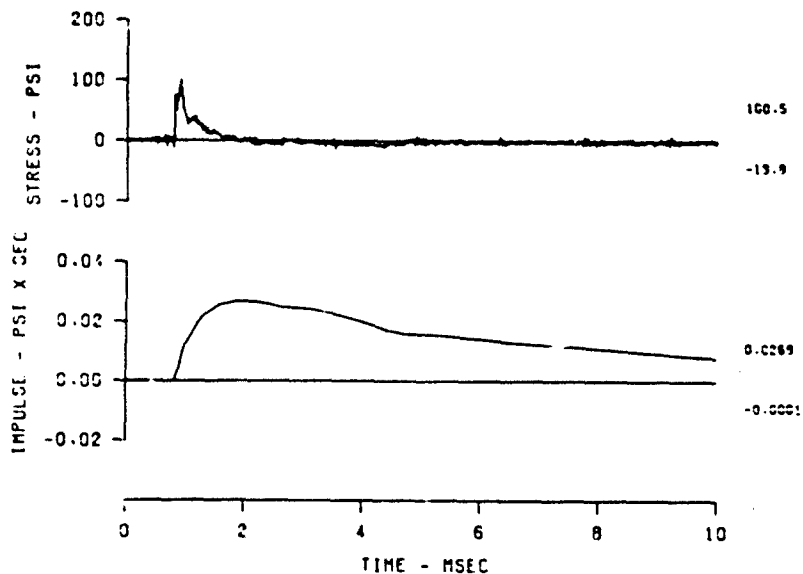


SHOT 24 CH 8 7
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500000.HZ 02/27/84

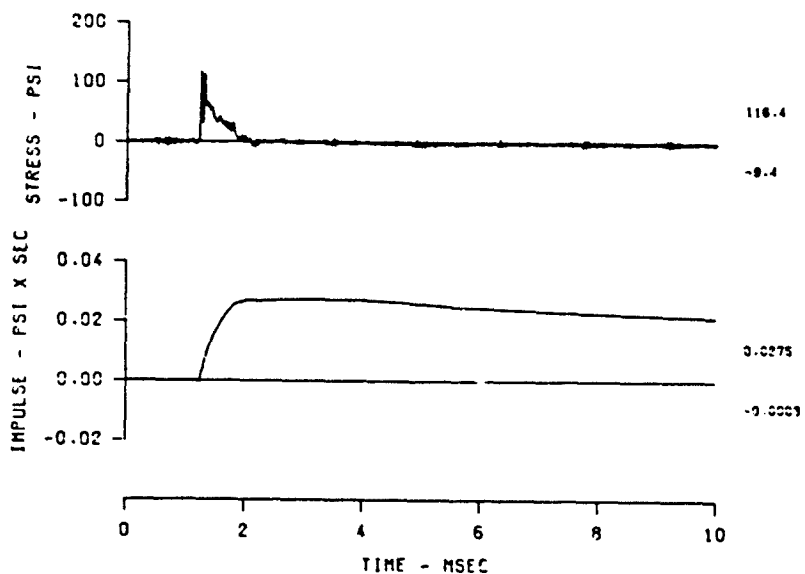


A194

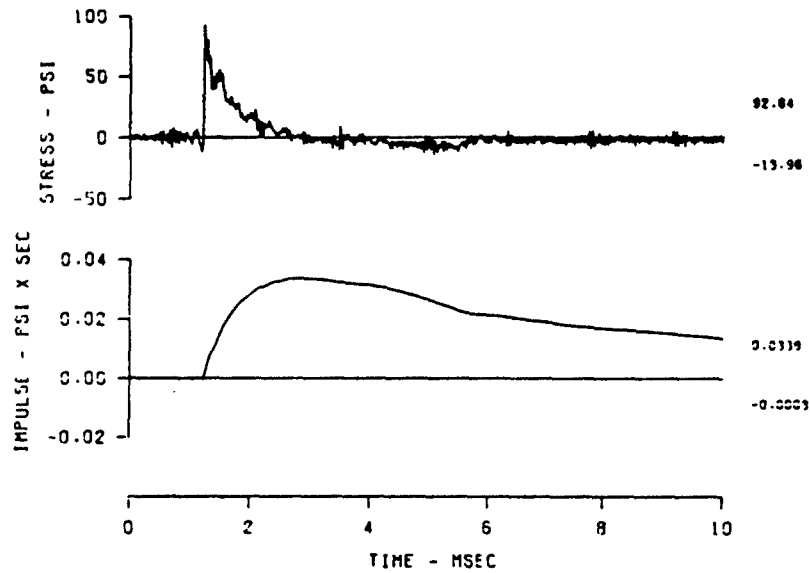
SHOT 24 CH 9 8
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



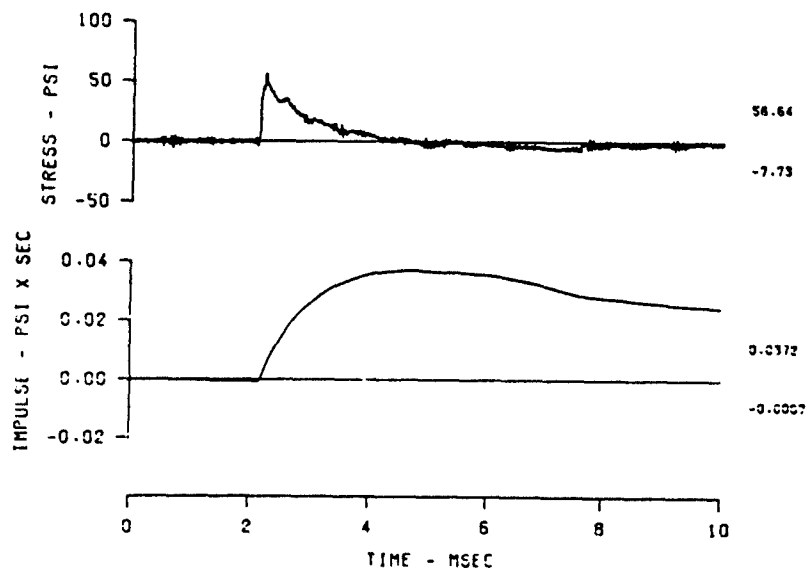
SHOT 24 CH 10 9
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



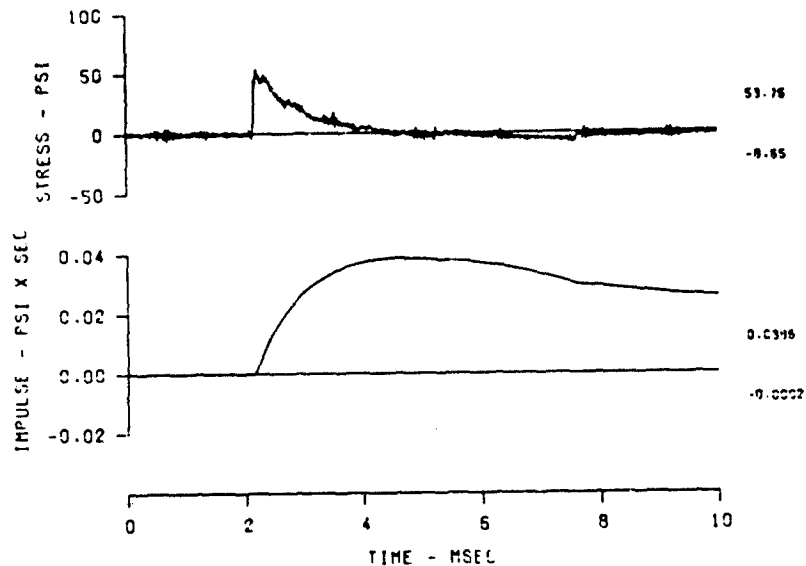
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500000.HZ 02/27/84



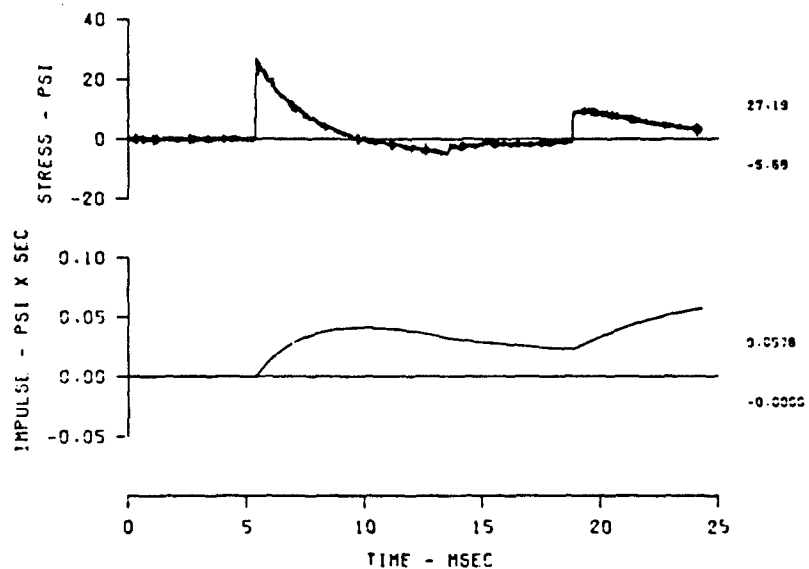
SHOT 24 CH 12 11
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



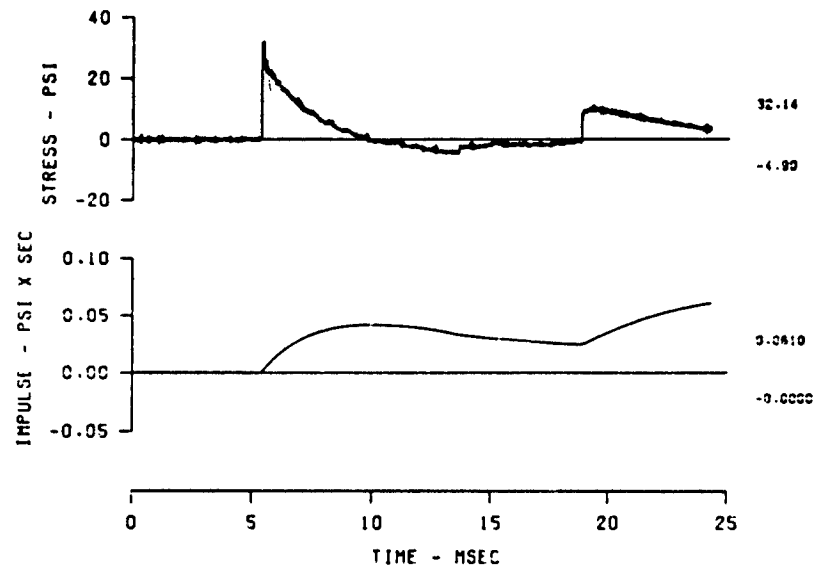
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 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



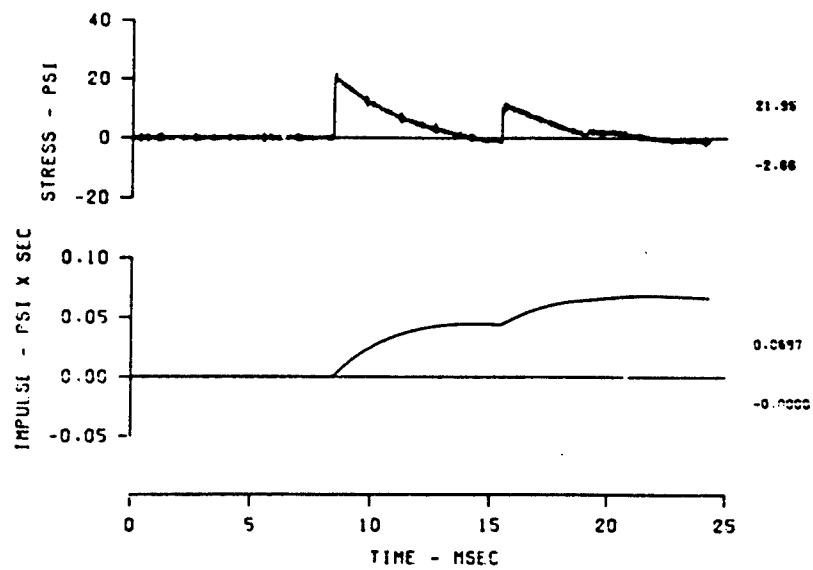
SHOT 24 CH 14 13
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



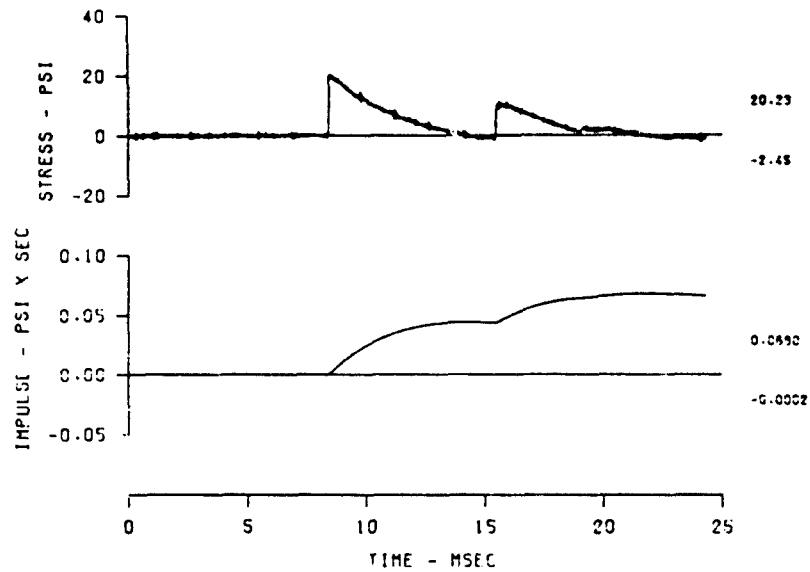
SHOT 24 CH 15 14
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500000.HZ 02/27/84



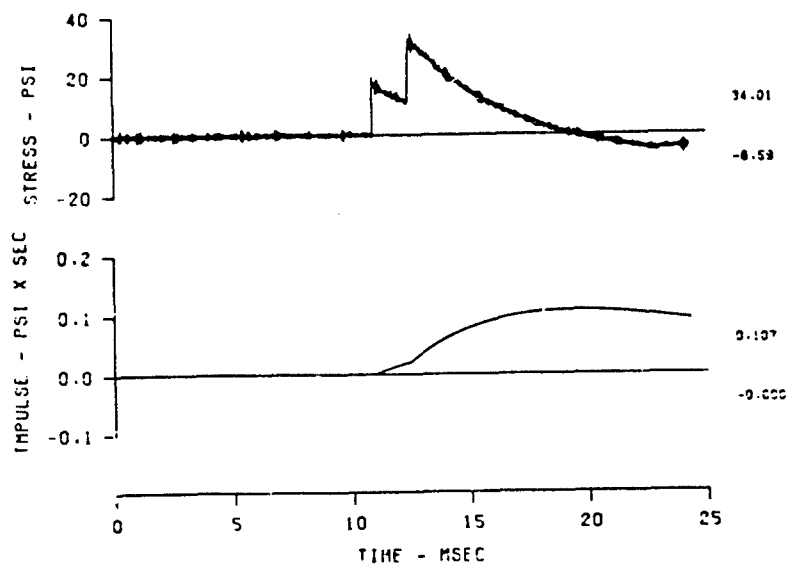
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500000.HZ 02/27/84



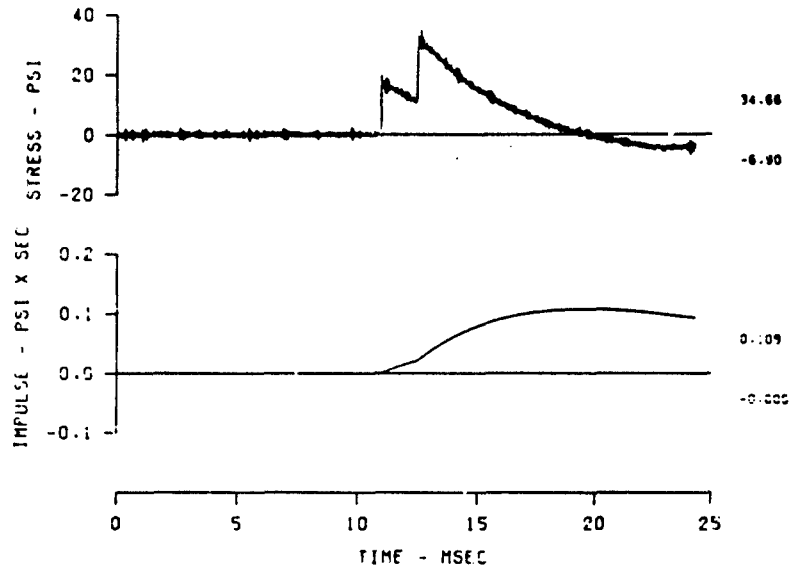
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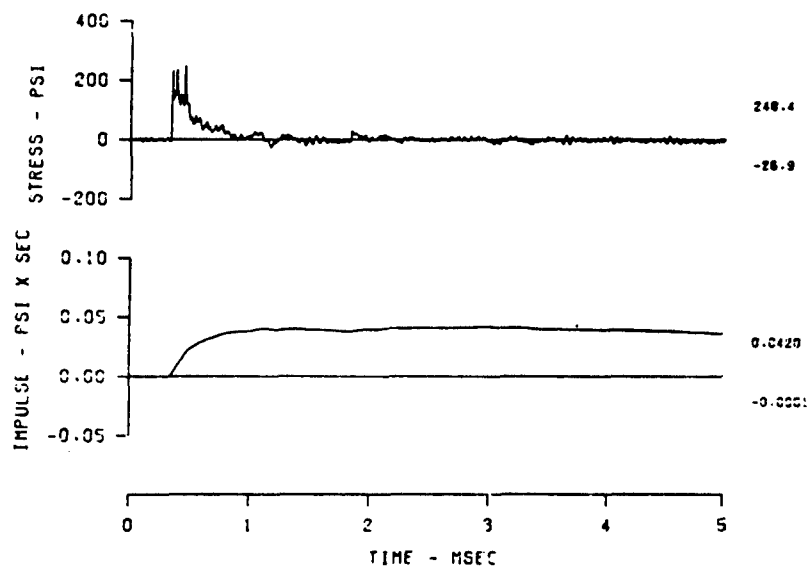
SHOT 24 CH 18 17
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



SHOT 24 CH 10 18
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

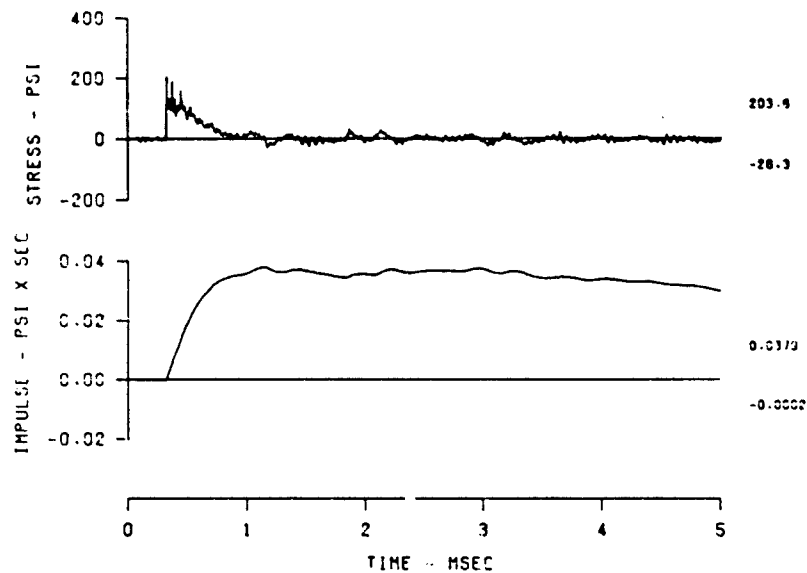


SHOT 25 CH 2 1
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

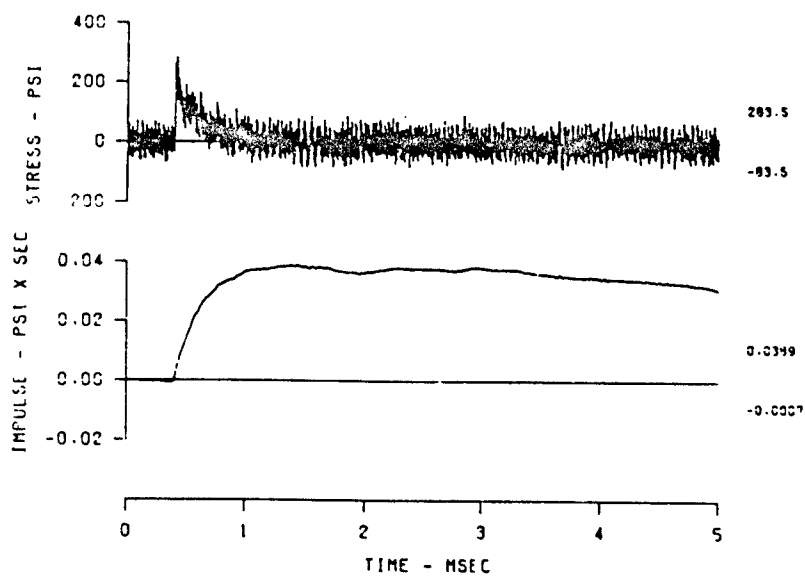


A200

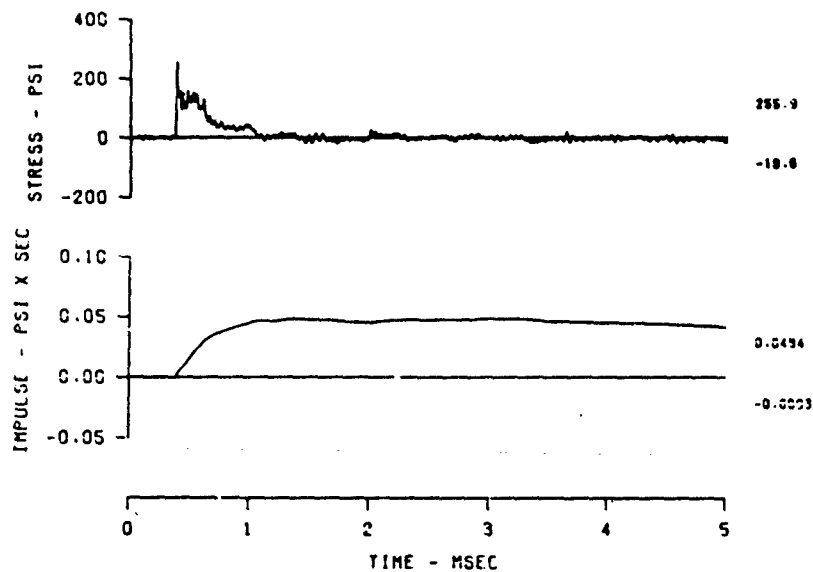
SHOT 25 CH 3 2
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



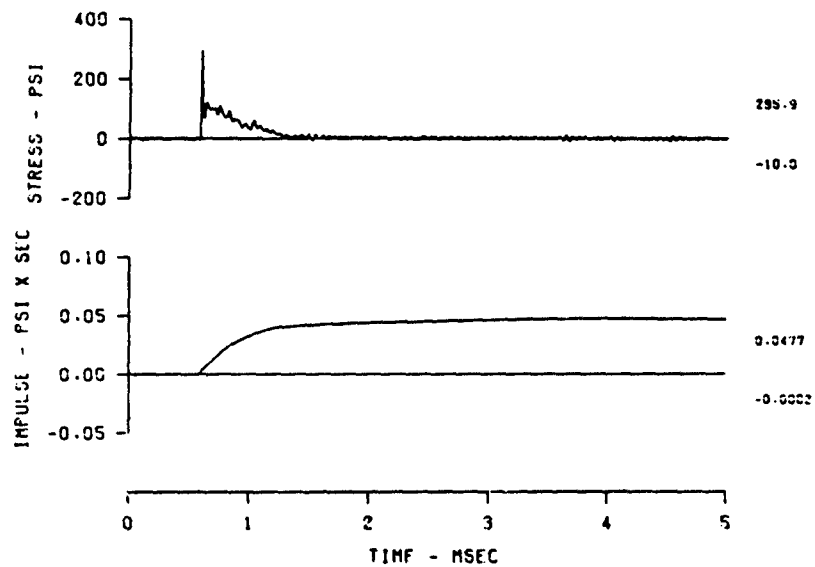
SHOT 25 CH 4 3
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



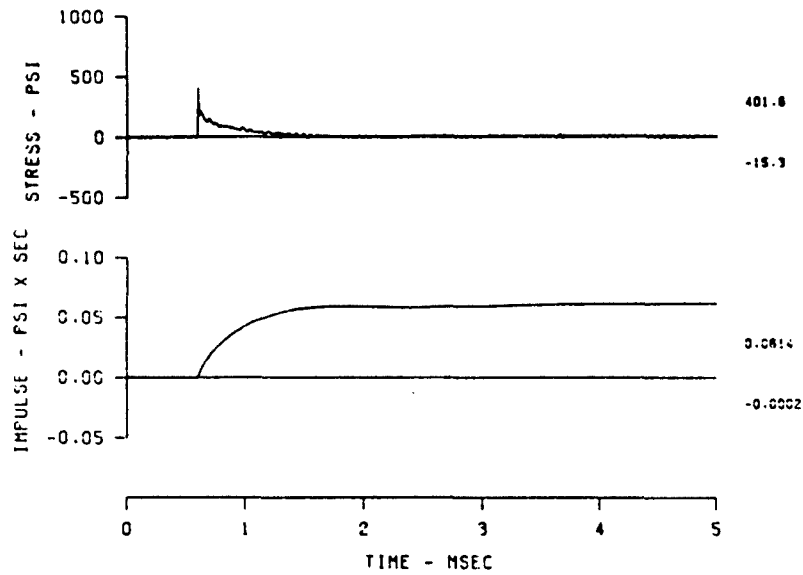
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500000.HZ 02/27/84



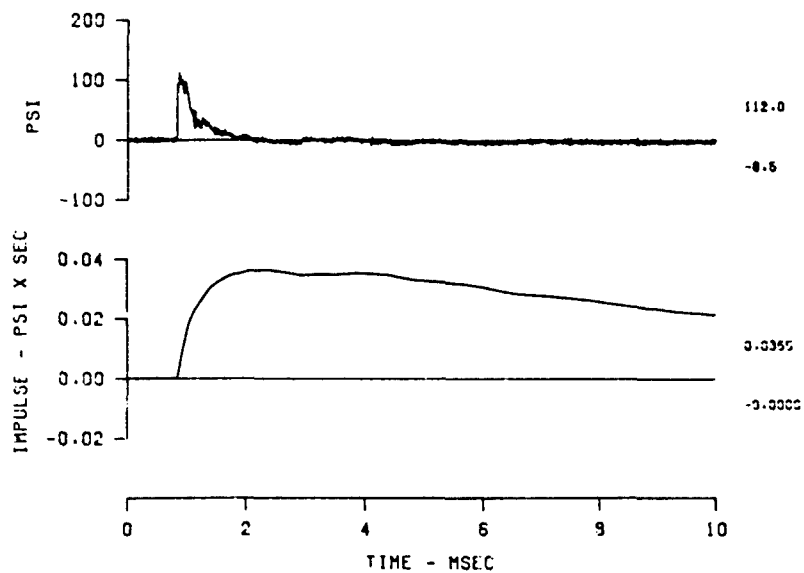
SHOT 25 CH 6 5
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



SHOT 25 CH 7 6
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

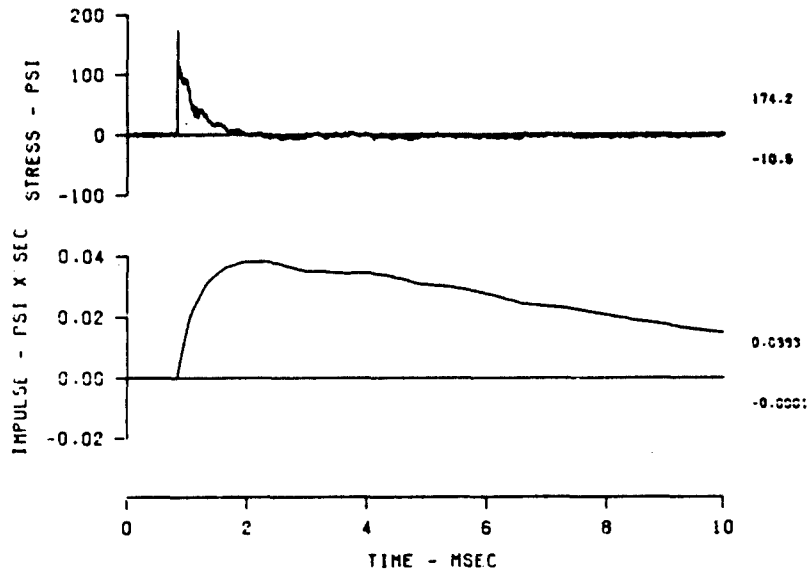


SHOT 25 CH 9 7
AIRBLAST PENETRATION 1983 6 INCH SQUARE TU
500000.HZ 03/13/84

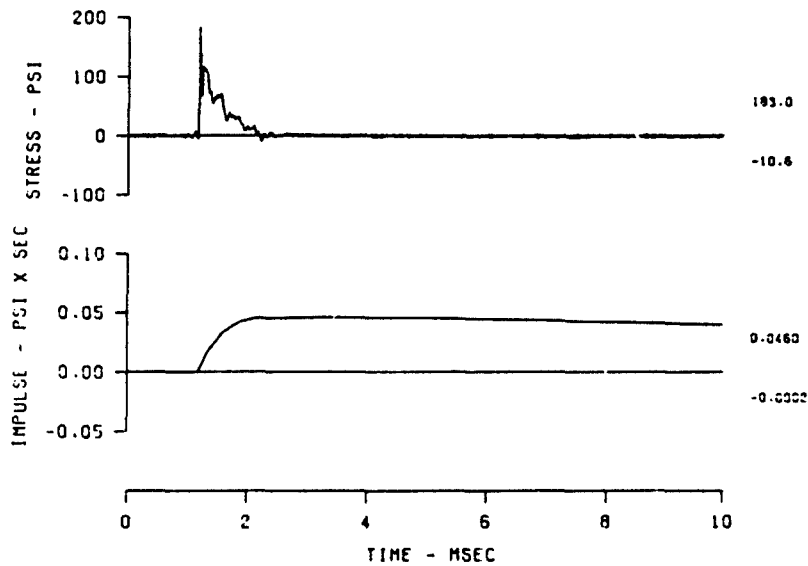


A203

SHOT 25 CH 9 8
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

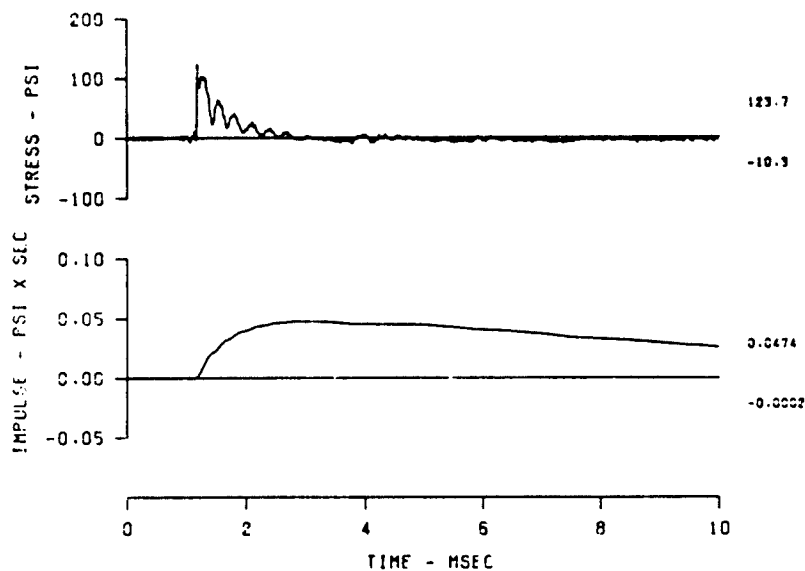


SHOT 25 CH 10 9
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

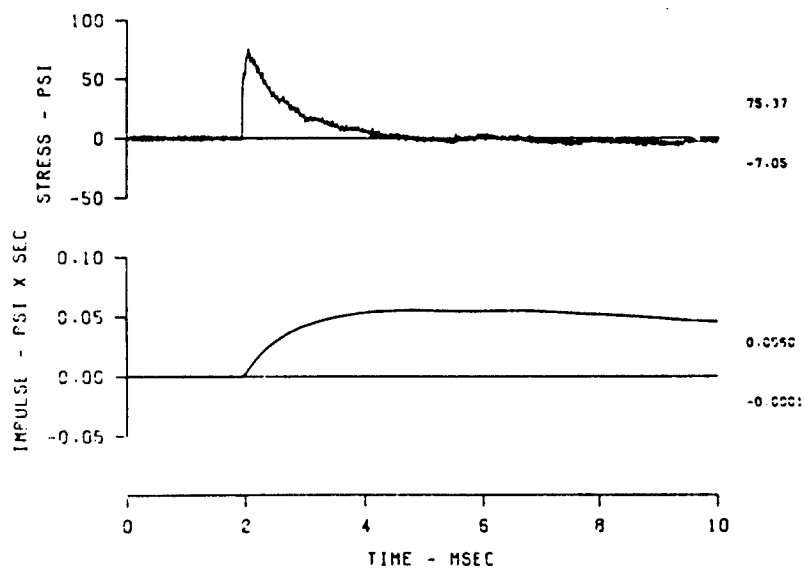


A204

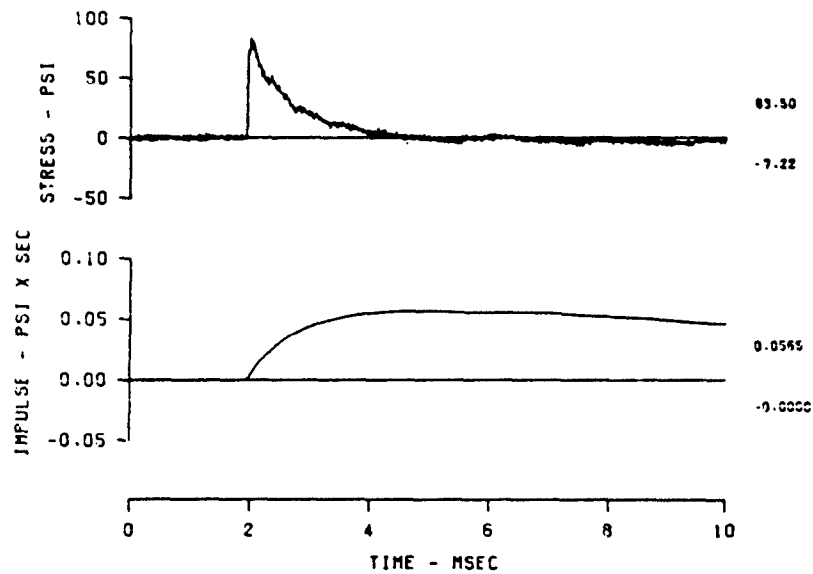
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 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



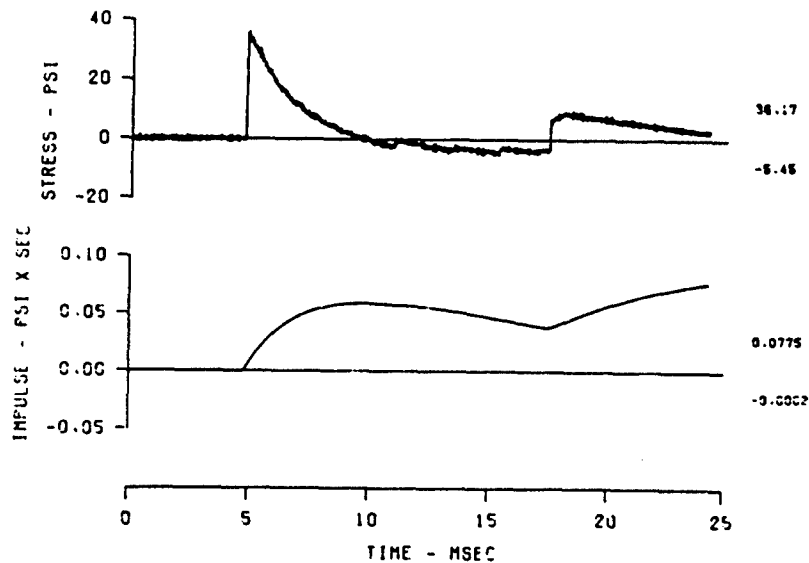
SHOT 25 CH 12 11
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000 HZ 02/27/84



SHOT 25 CH 13 12
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

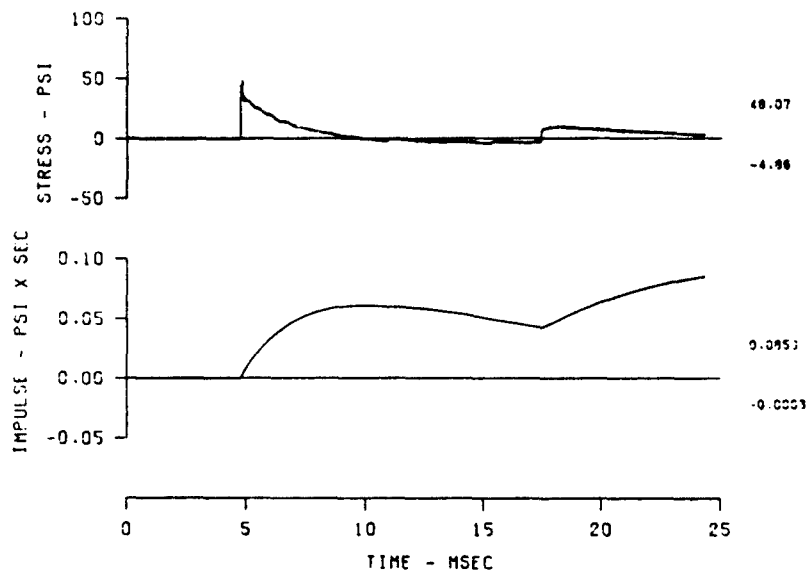


SHOT 25 CH 14 13
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

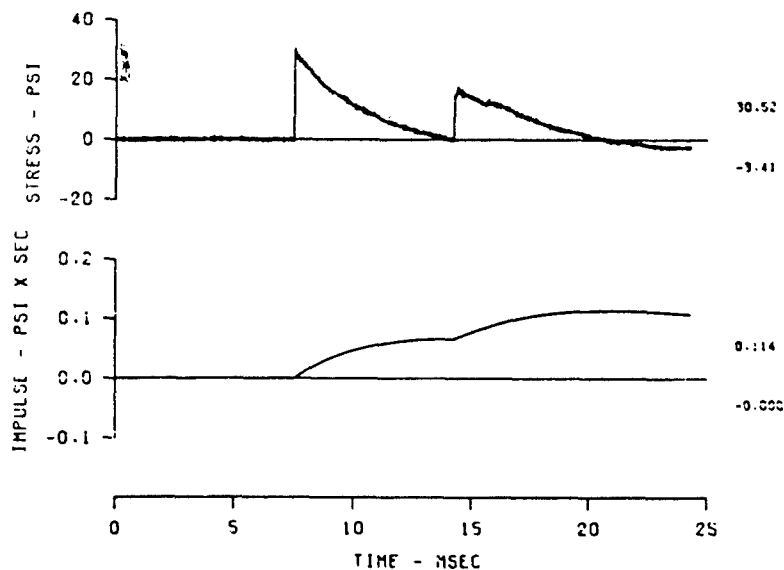


A206

SHOT 25 CM 15 14
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

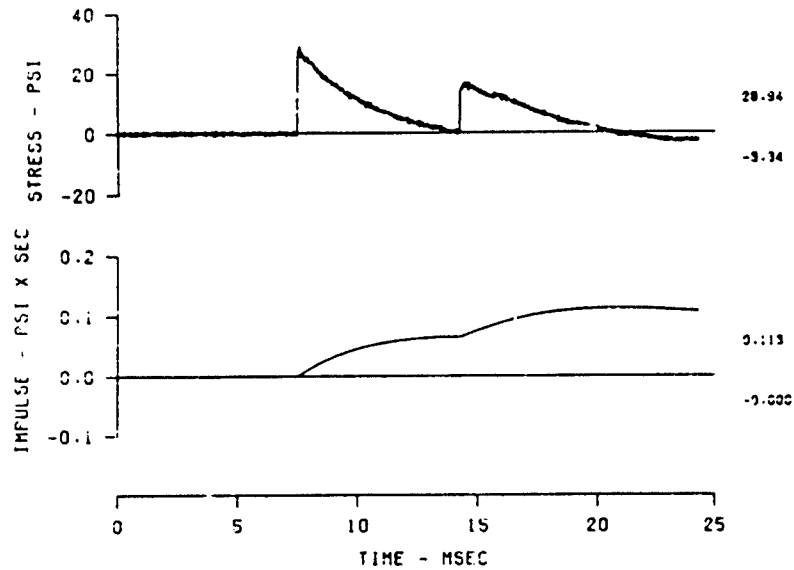


SHOT 25 CM 16 15
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

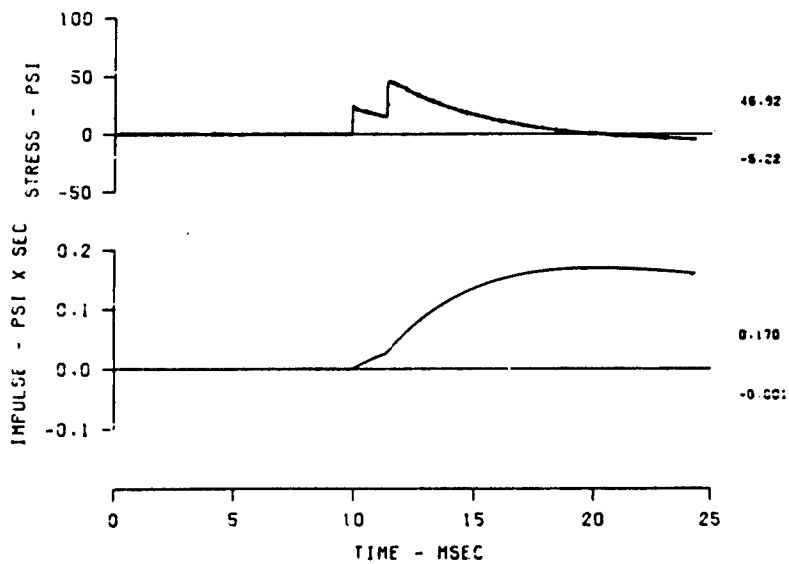


A207

SHOT 25 CH 17 16
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

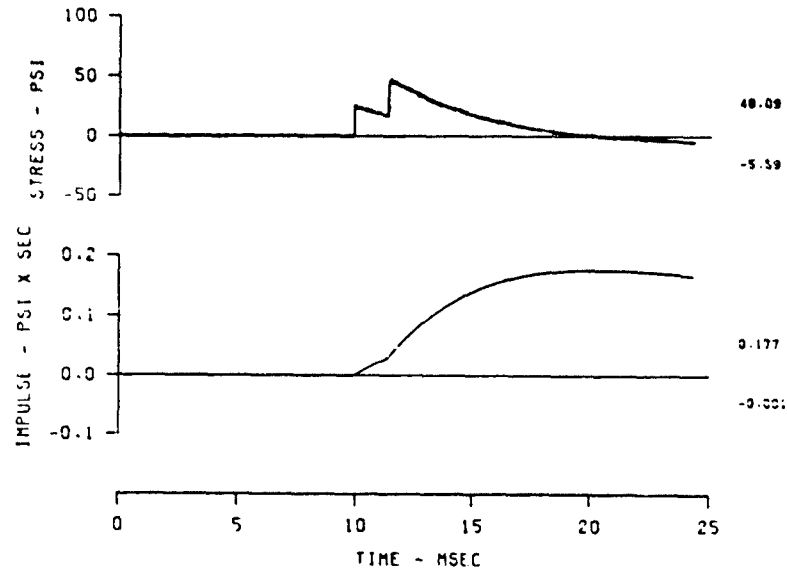


SHOT 25 CH 18 17
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

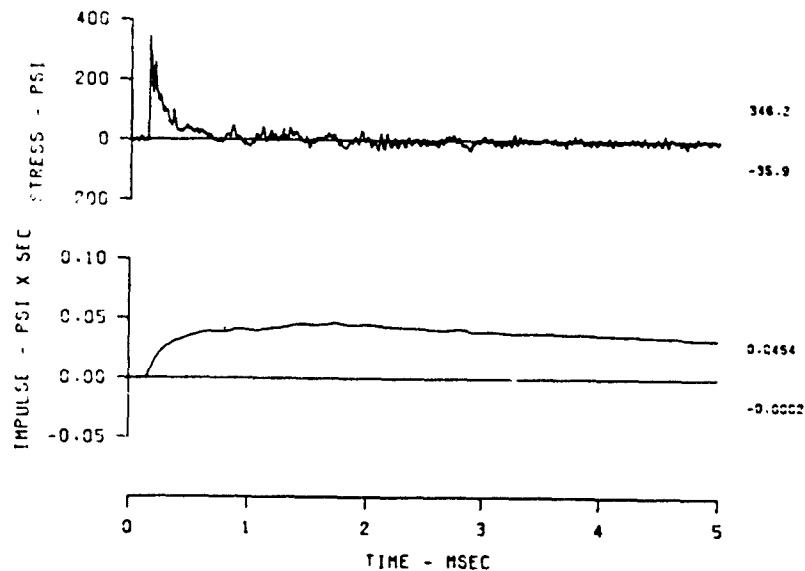


A208

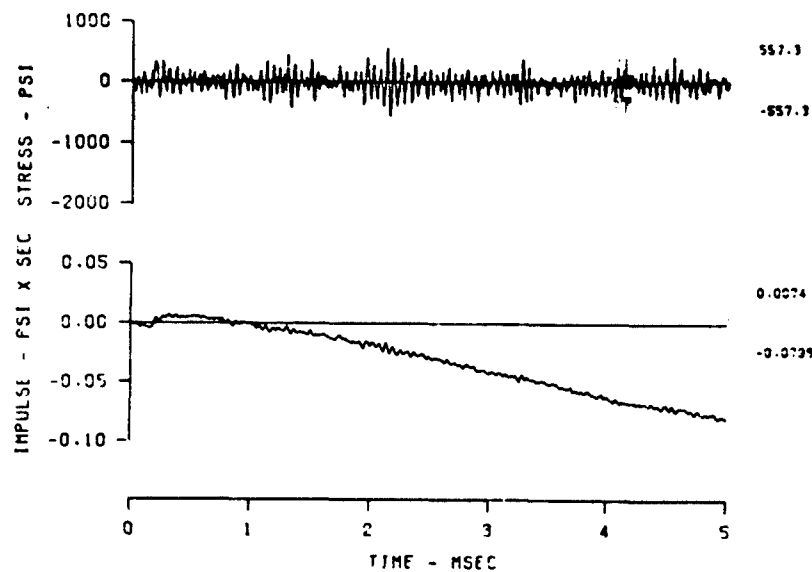
SHOT 25 CH 19 18
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



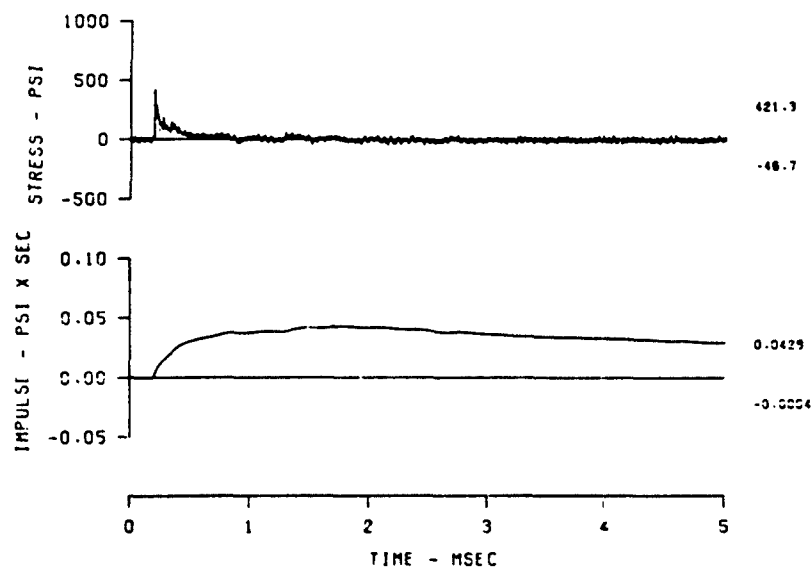
SHOT 26 CH 2 1
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



SHOT 26 CH 3 2
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

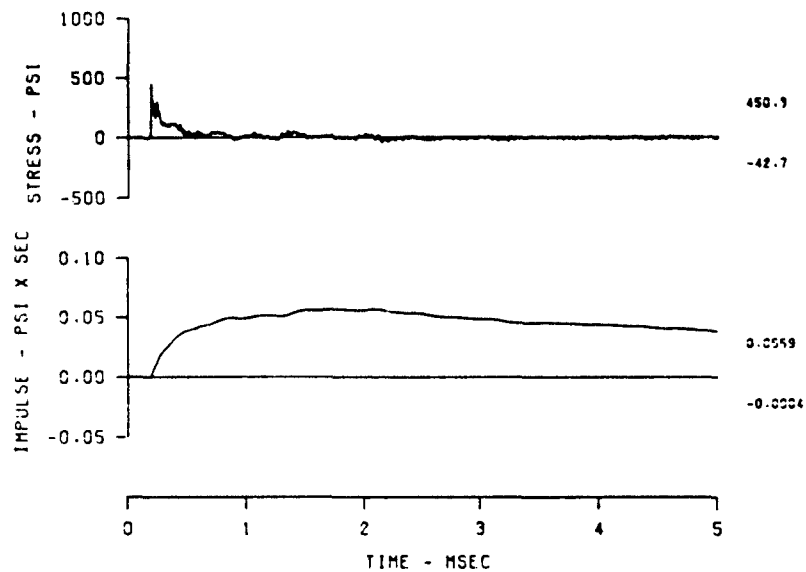


SHOT 26 CH 4 3
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500000.HZ 02/27/84

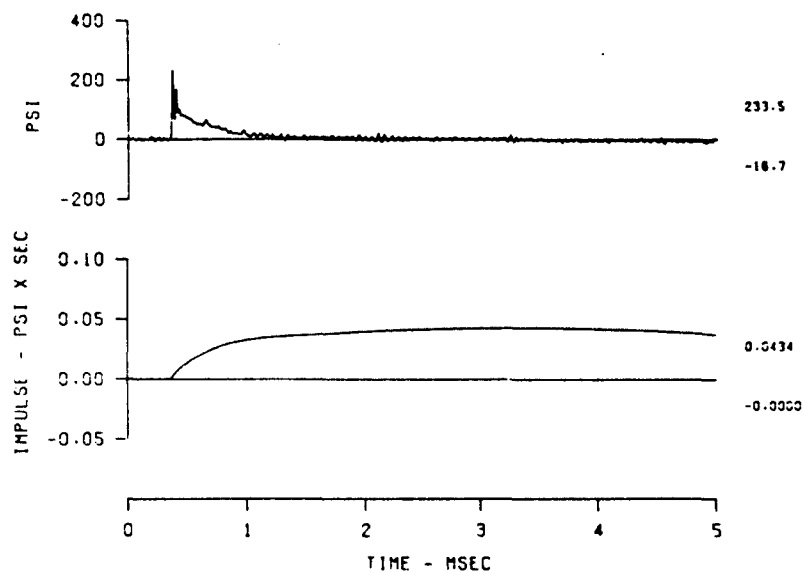


A210

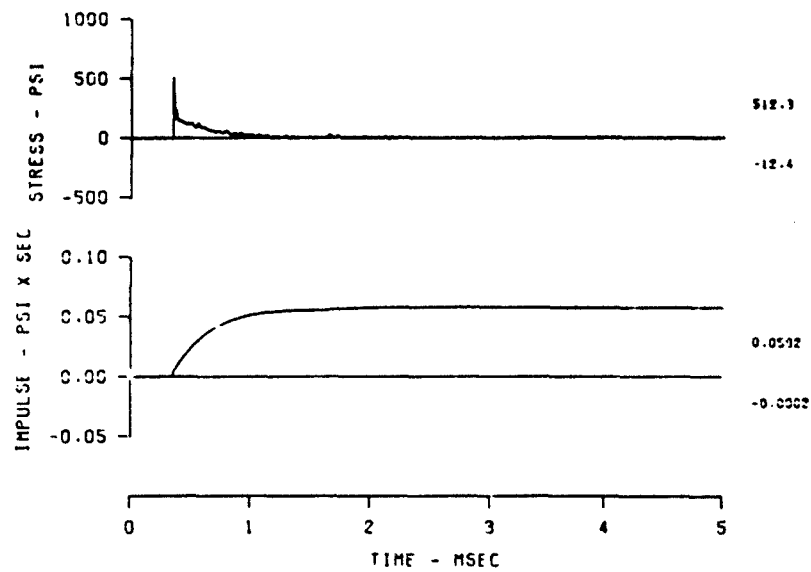
SHOT 26 CH 5 4
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.MZ 02/27/84



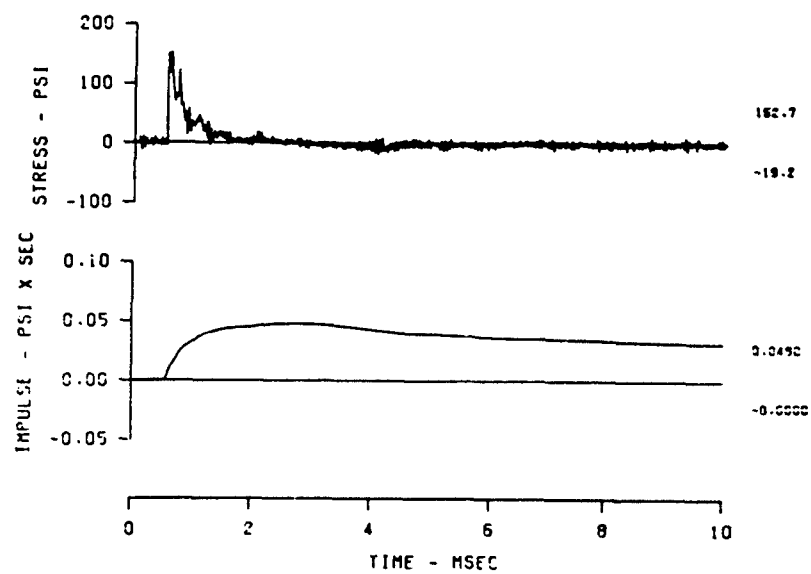
SHOT 26 CH 6 5
AIRBLAST PENETRATION 1983 6 INCH SQUARE T1
500000.MZ 06/12/84



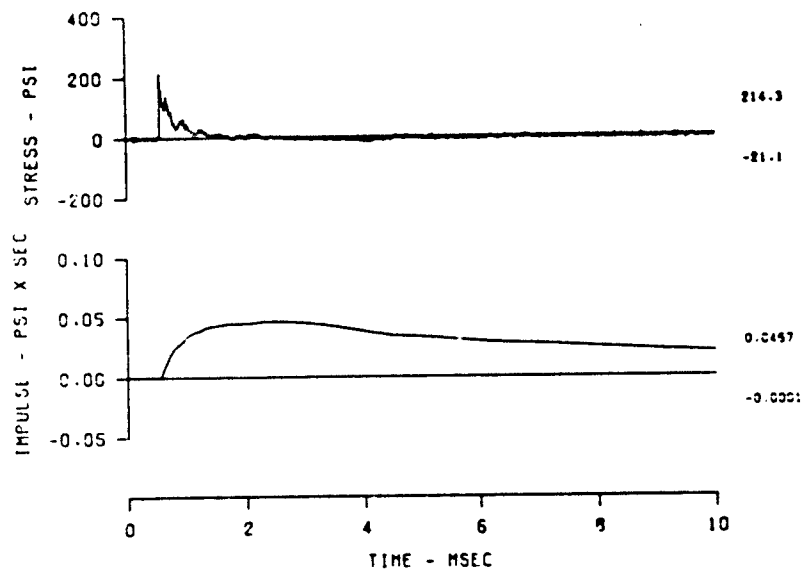
SHOT 26 CH 7 6
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



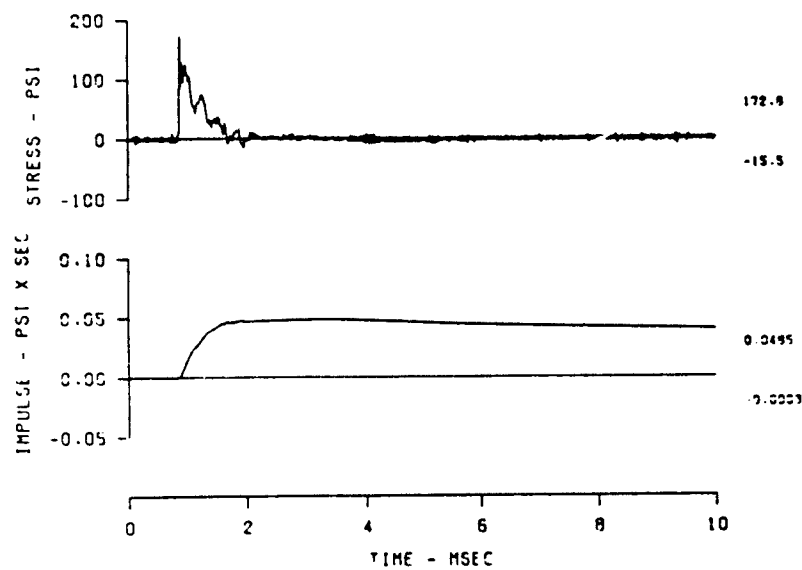
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500000.HZ 02/27/84



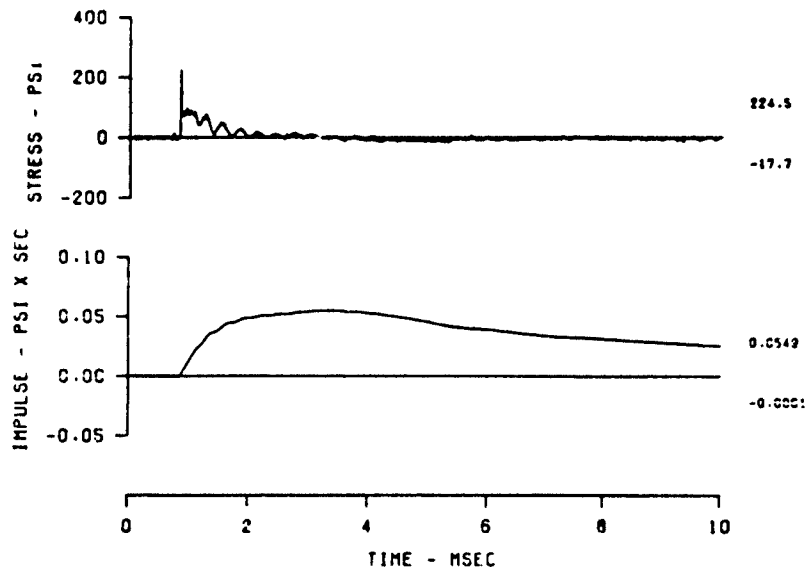
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 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



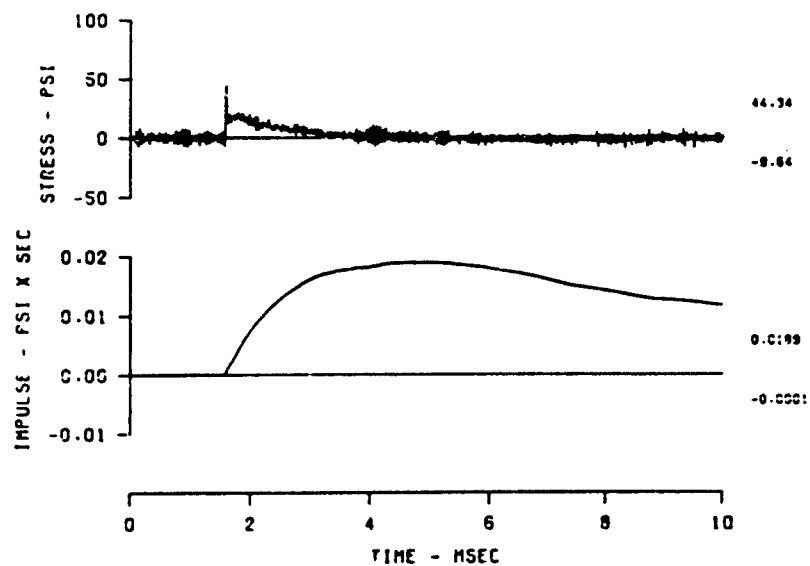
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 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



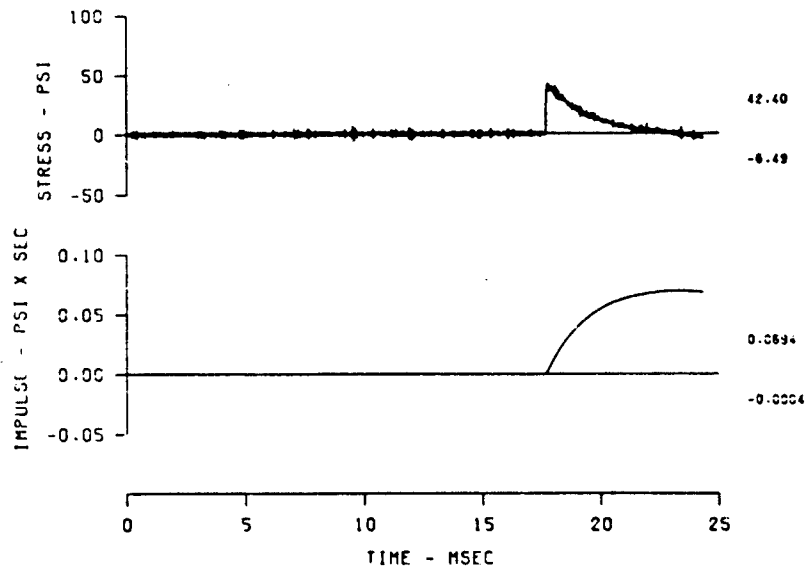
SHOT 26 CH 11 10
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



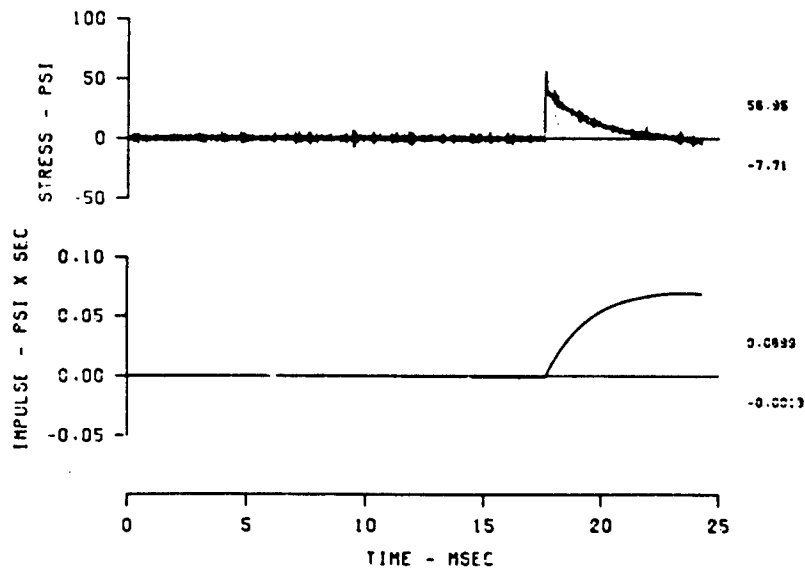
SHOT 26 CH 13 12
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



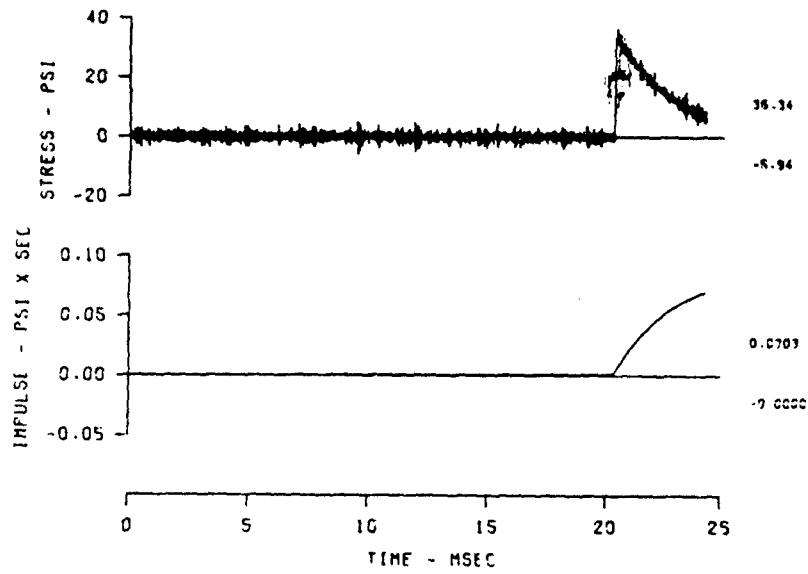
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 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



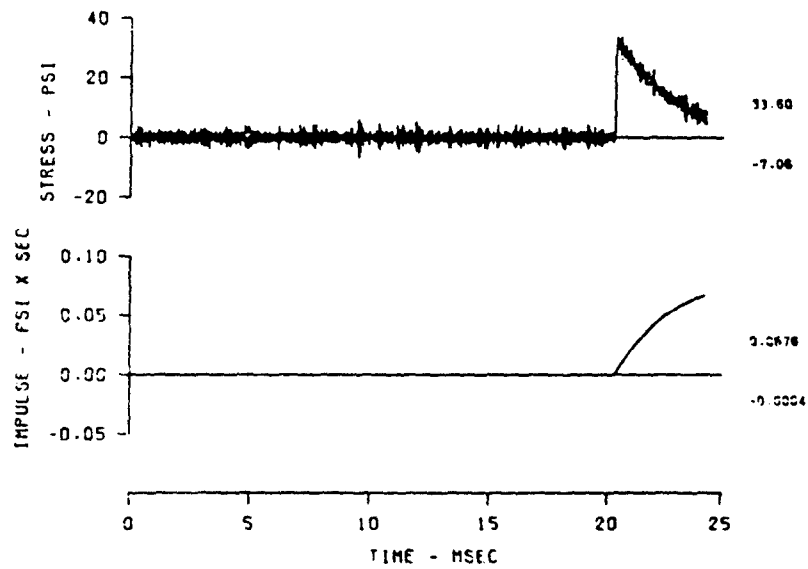
SHOT 26 CH 15 14
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



SHOT 26 CH 16 15
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

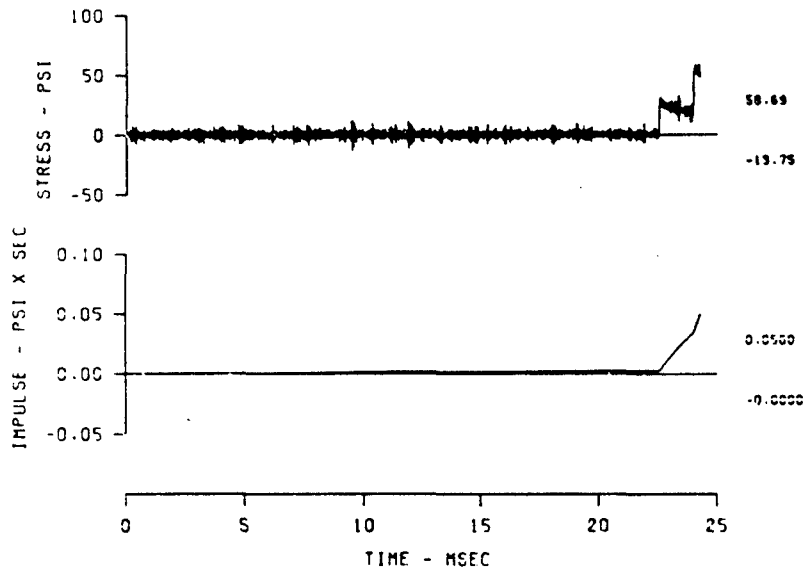


SHOT 26 CH 17 16
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

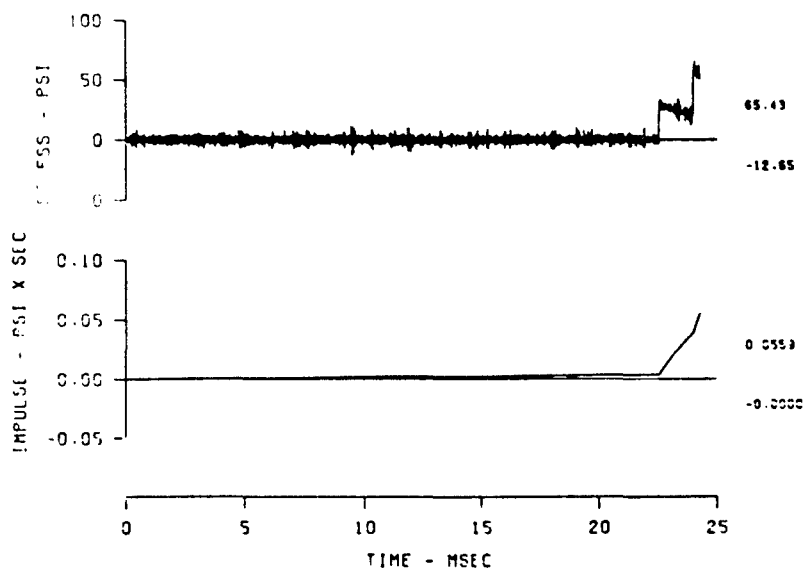


A216

SHOT 26 CH 18 17
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

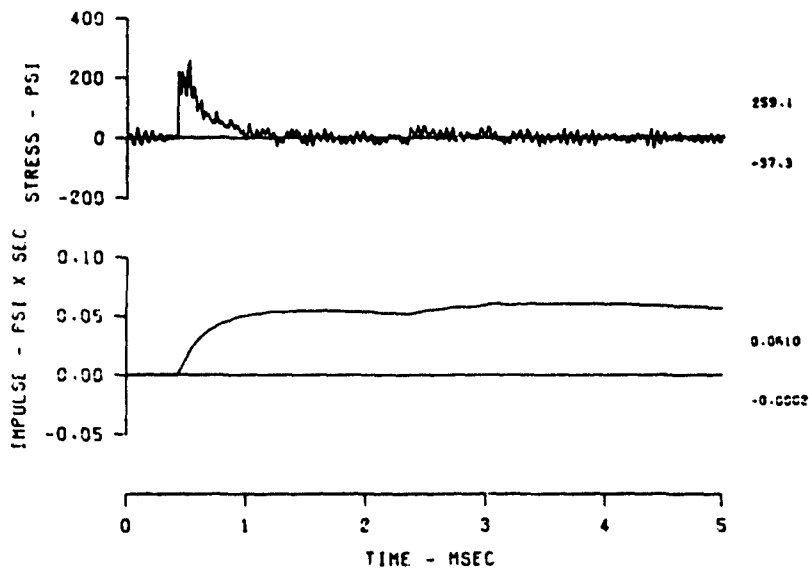


SHOT 26 CH 19 18
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

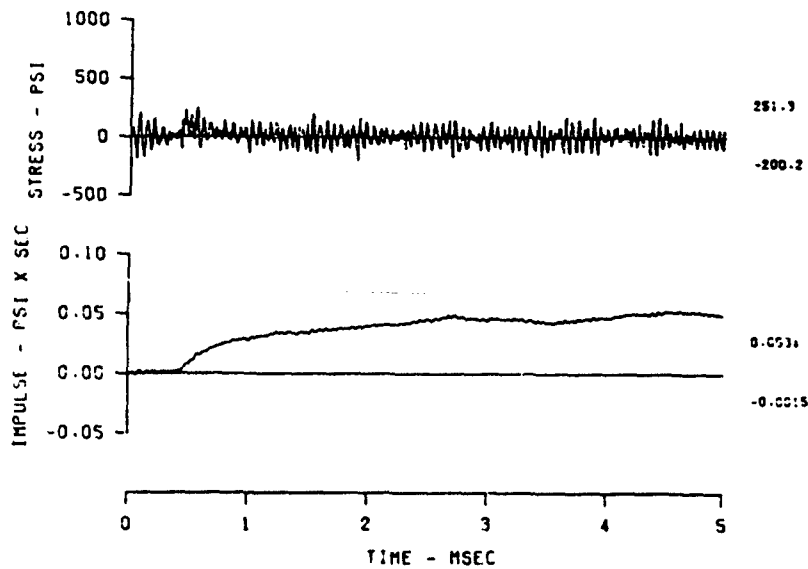


A217

SHOT 27 CH 2 1
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

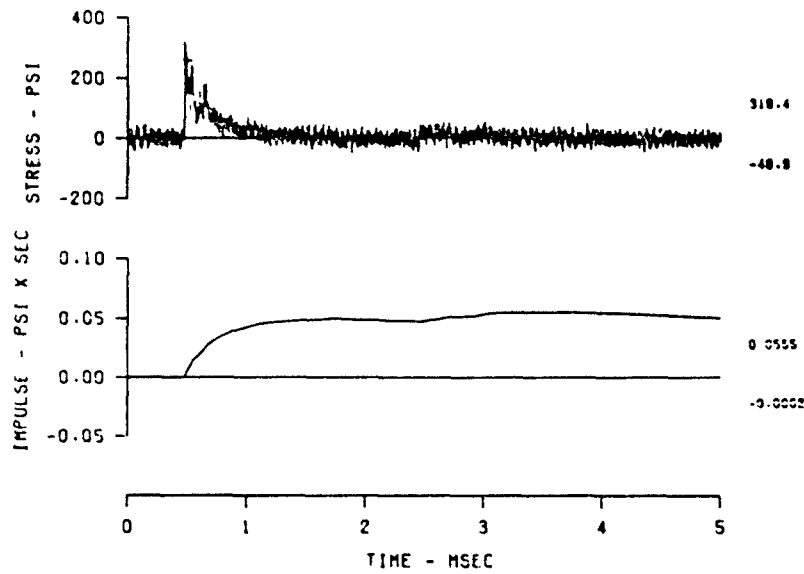


SHOT 27 CH 3 2
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

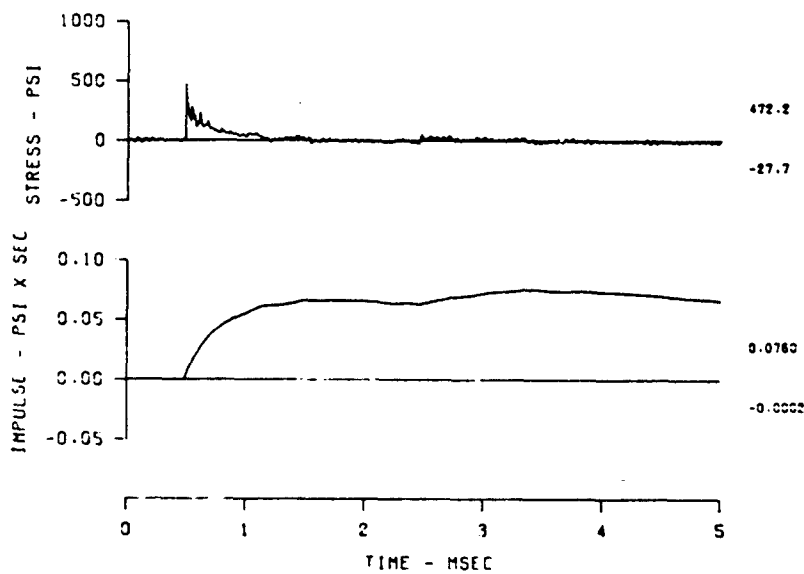


A218

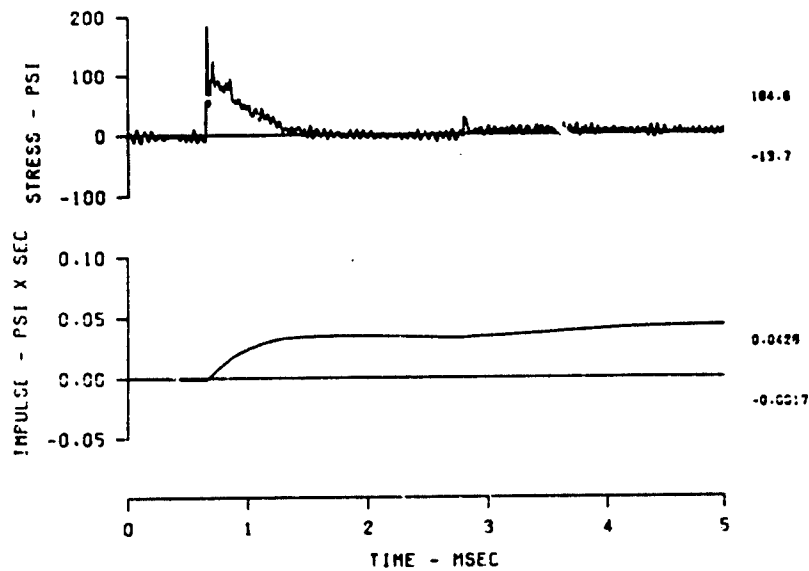
SHOT 27 CH 4 3
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



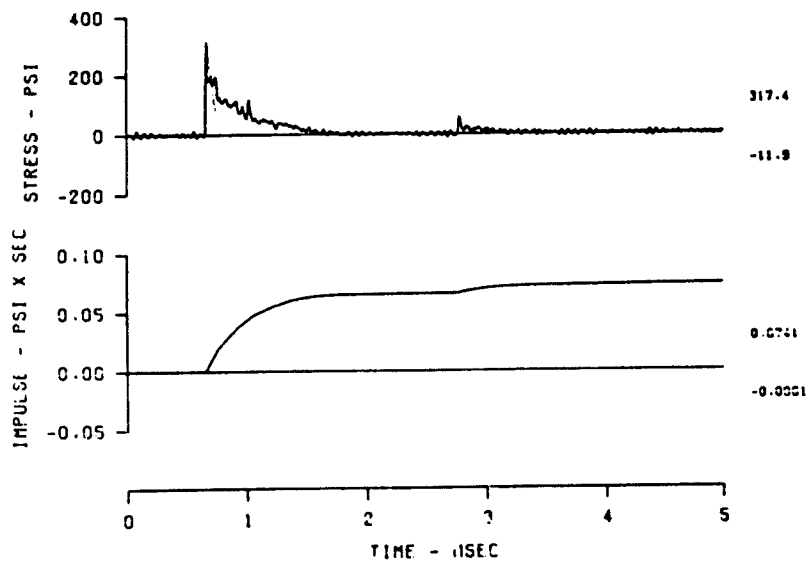
SHOT 27 CH 5 4
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



SHOT 27 CH 6 5
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500000.HZ 02/27/84

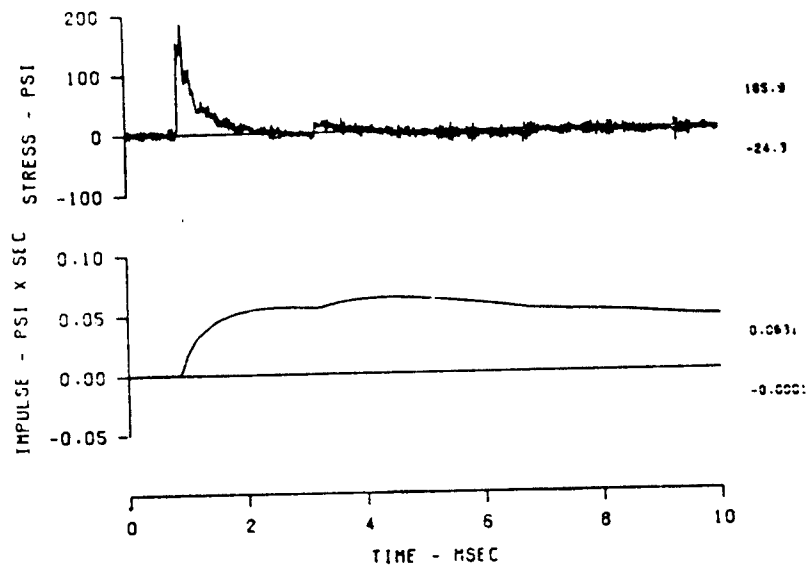


SHOT 27 CH 7 6
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

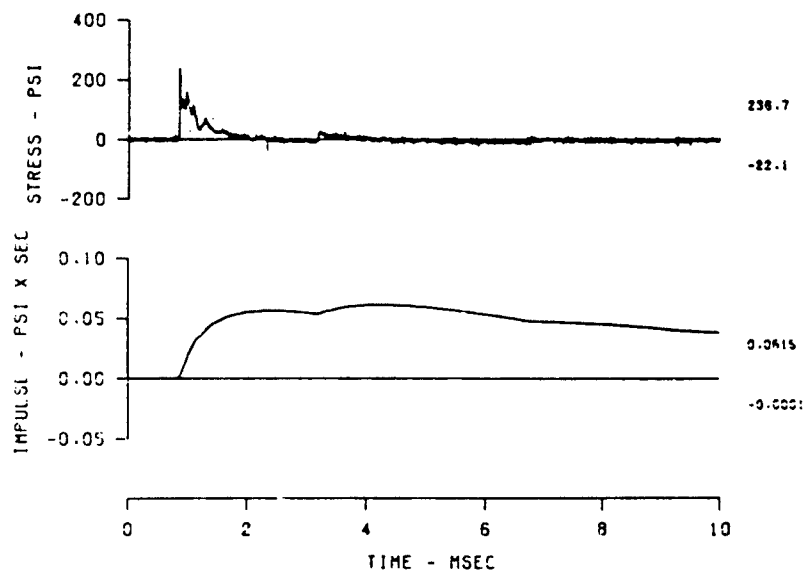


A220

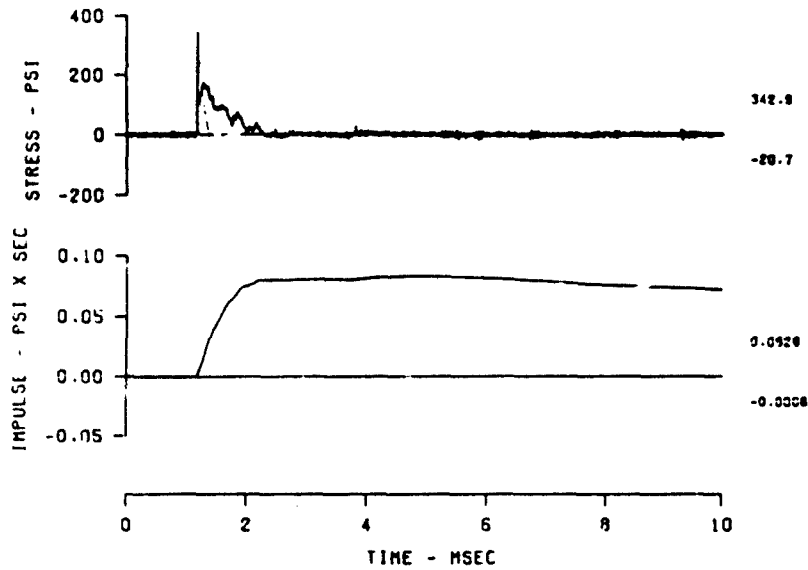
SHOT 27 CH 8 7
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



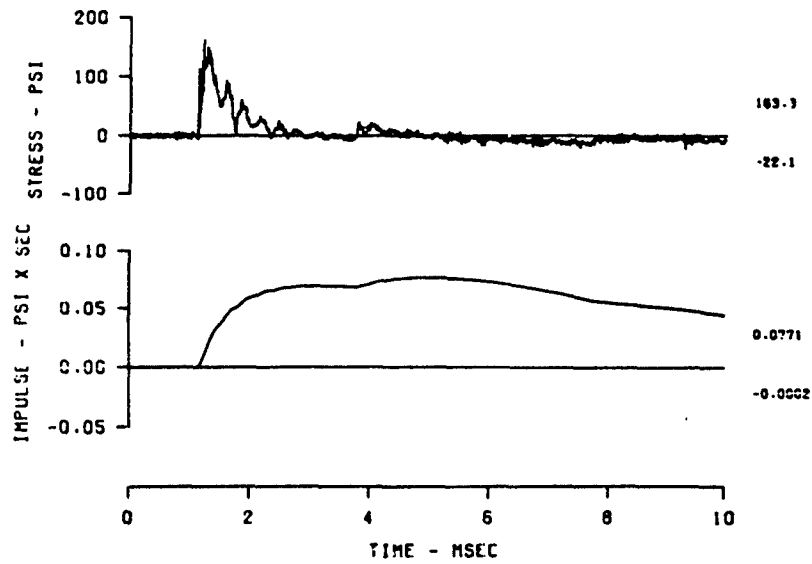
SHOT 27 CH 9 8
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



SHOT 27 CH 10 9
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

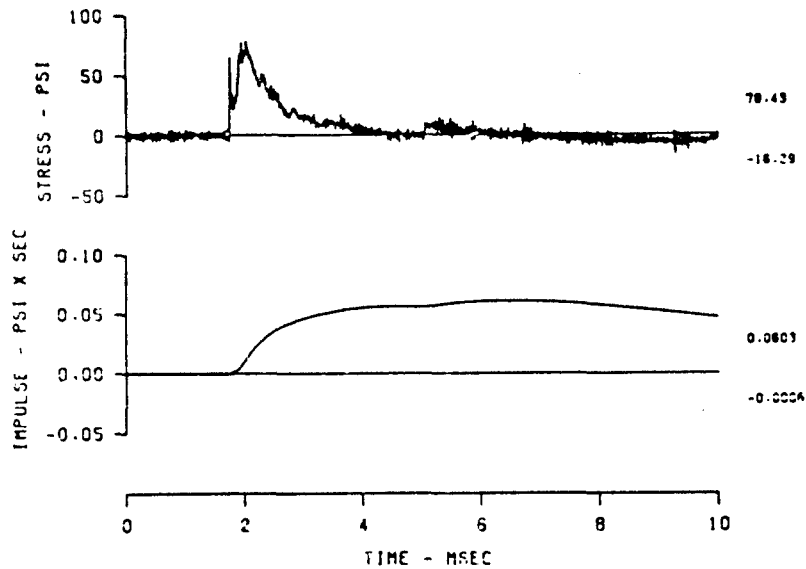


SHOT 27 CH 11 10
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

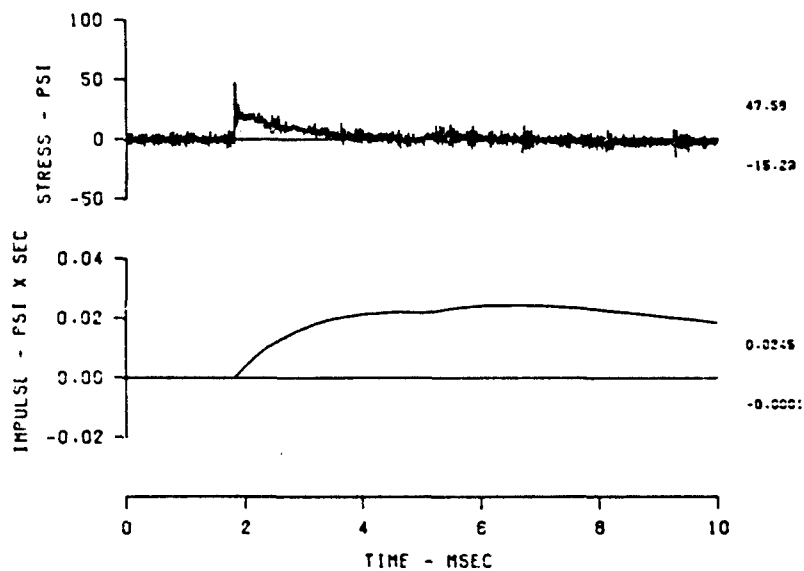


A222

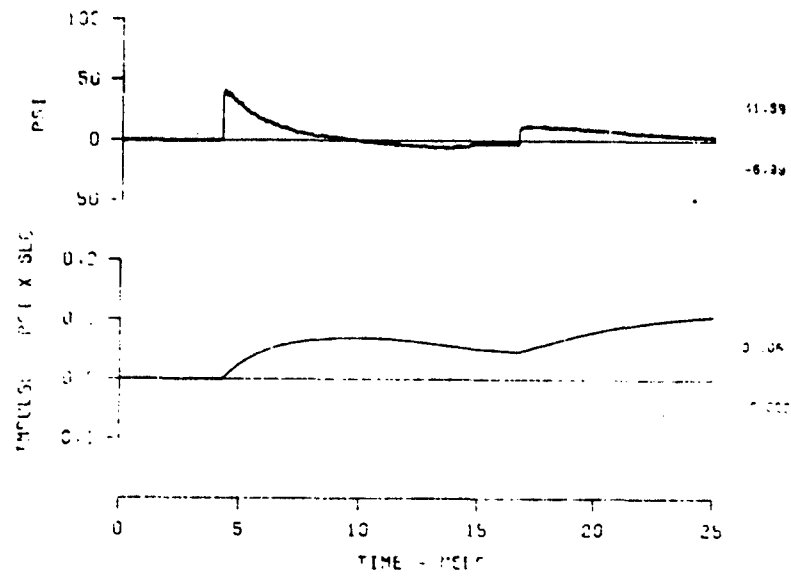
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 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



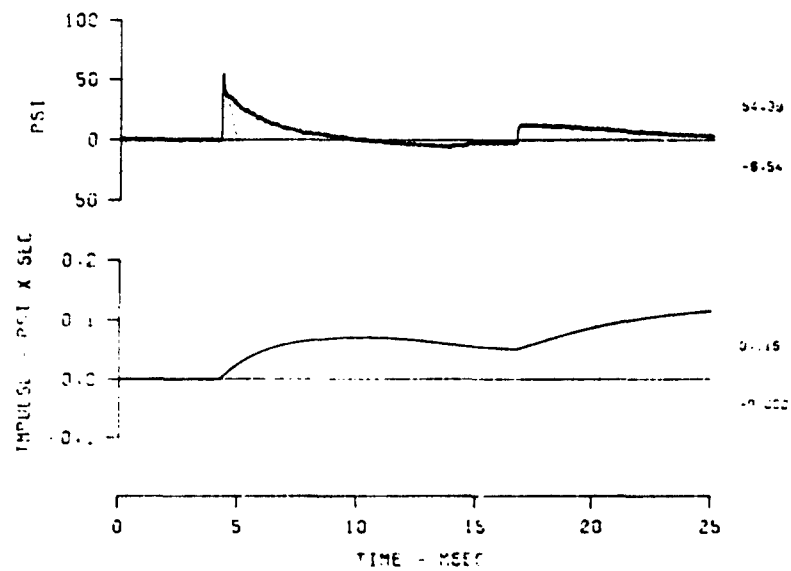
SHOT 27 CH 13 12
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



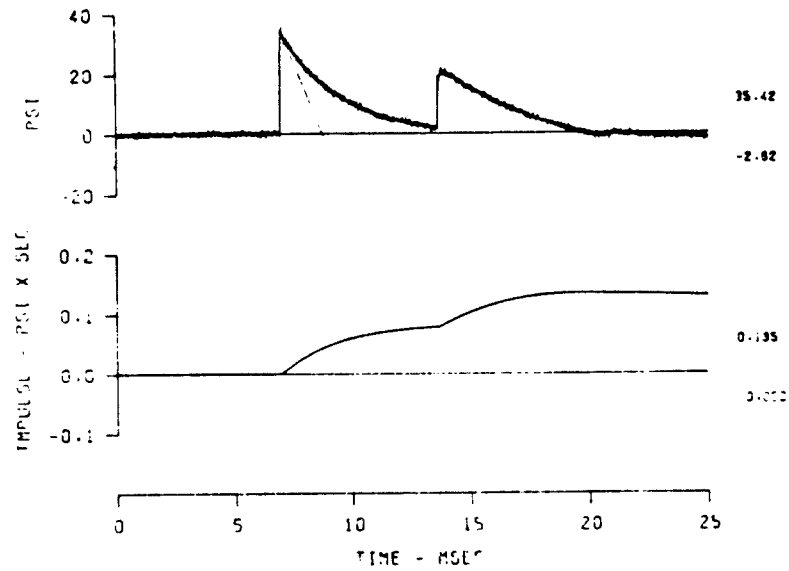
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 AIRBLAST PENETRATION 1983 5 INCH SQUARE
 500000 HZ 03/21/94



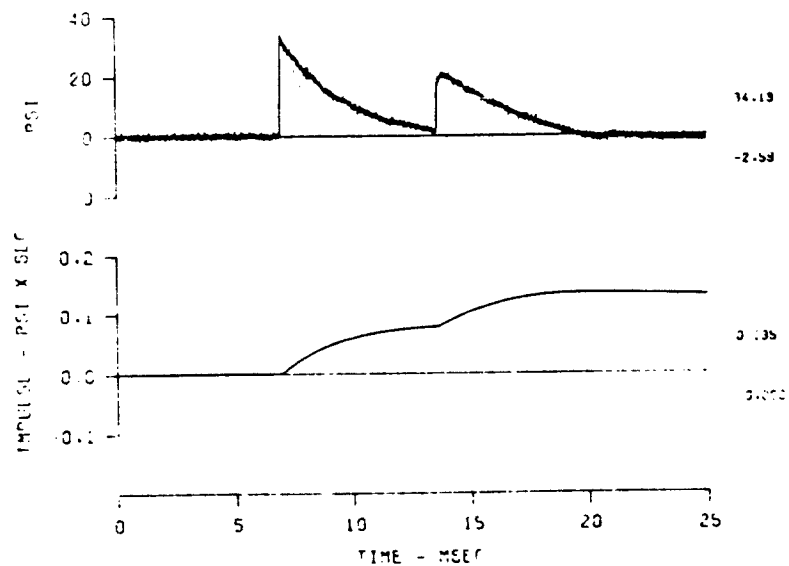
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 500000 HZ 03/21/94



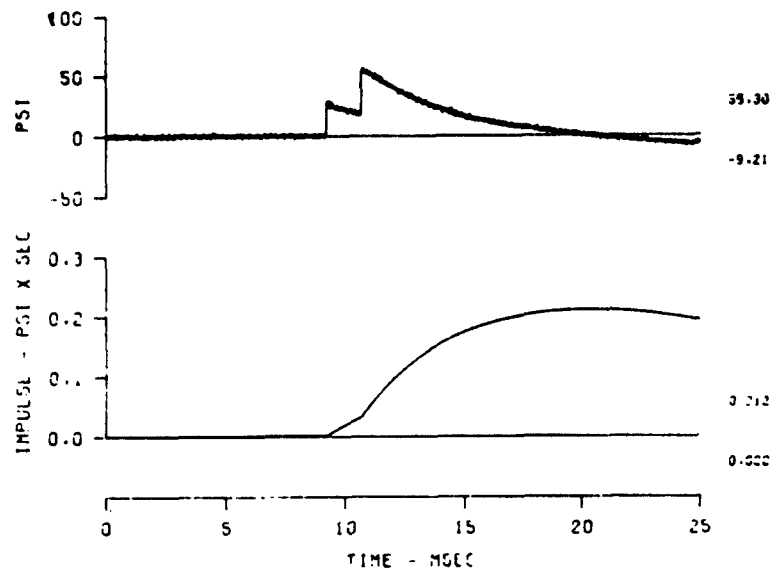
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 500000.HZ 03/21/94



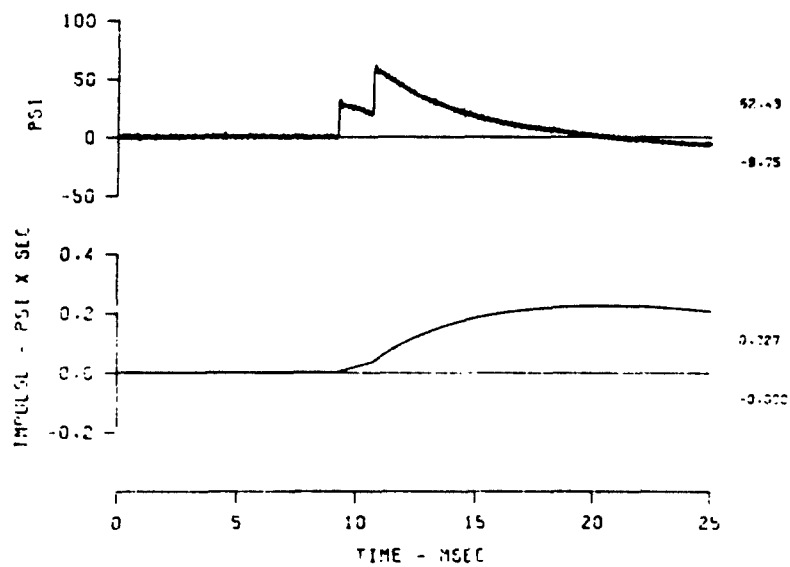
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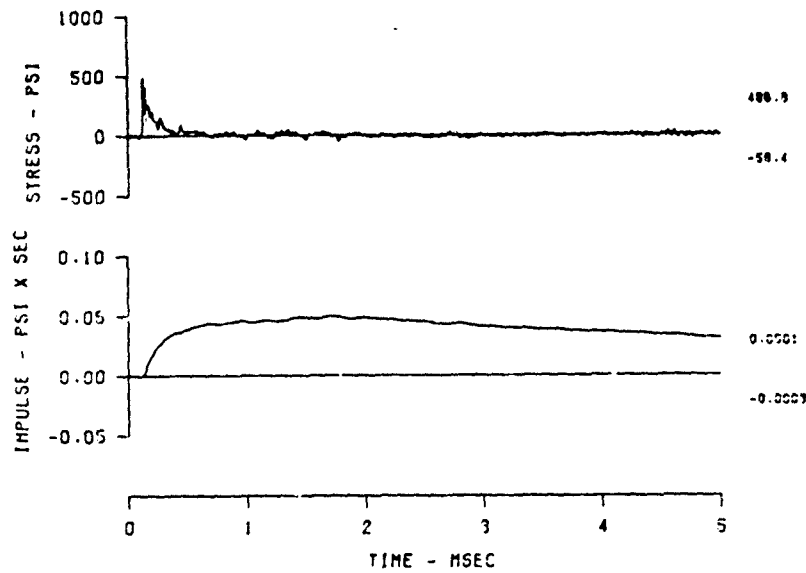
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 AIRBLAST PENETRATION 1993 6 INCH SQUARE TO
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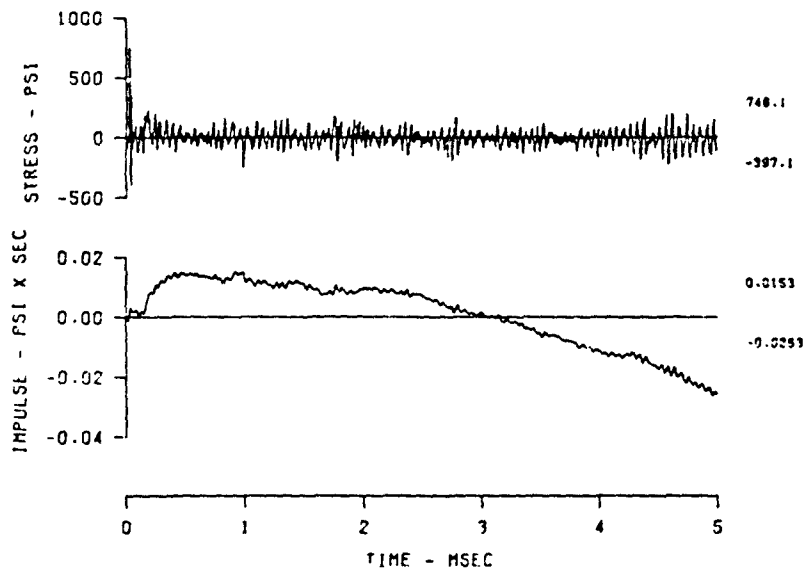
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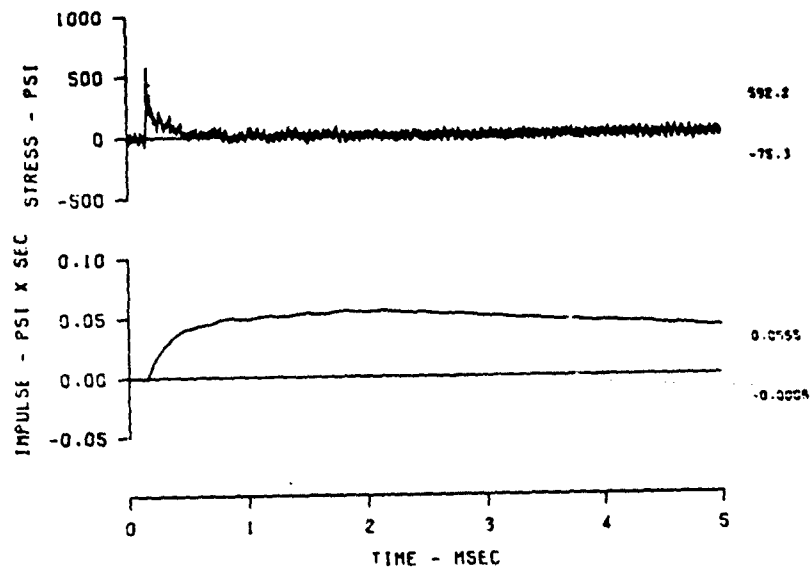
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 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



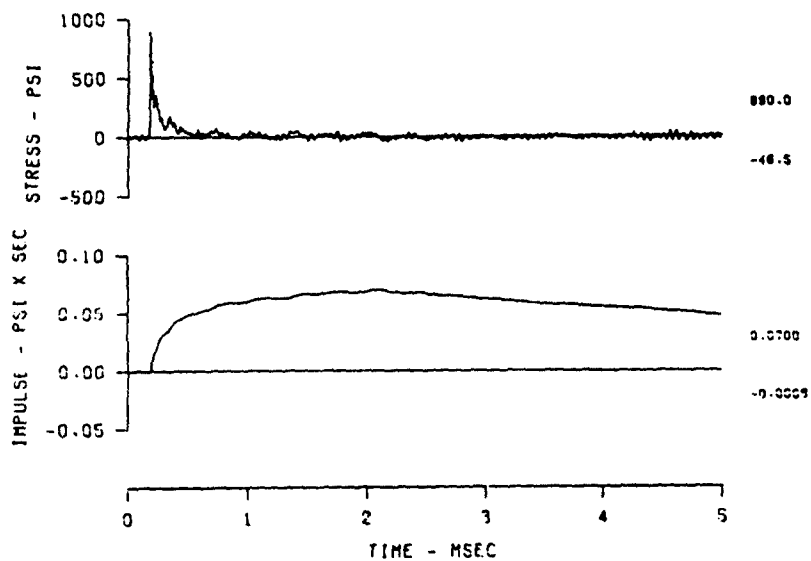
SHOT 28 CH 3 2
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



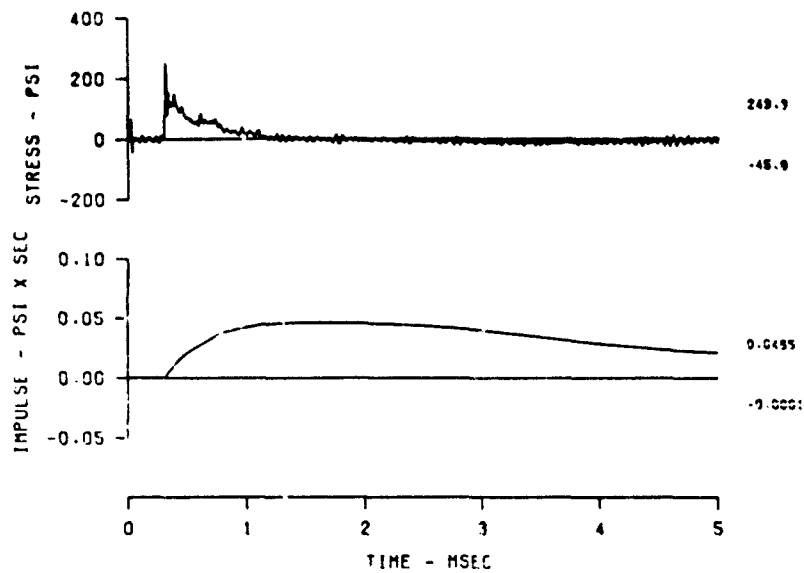
SHOT 28 CH 4 3
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



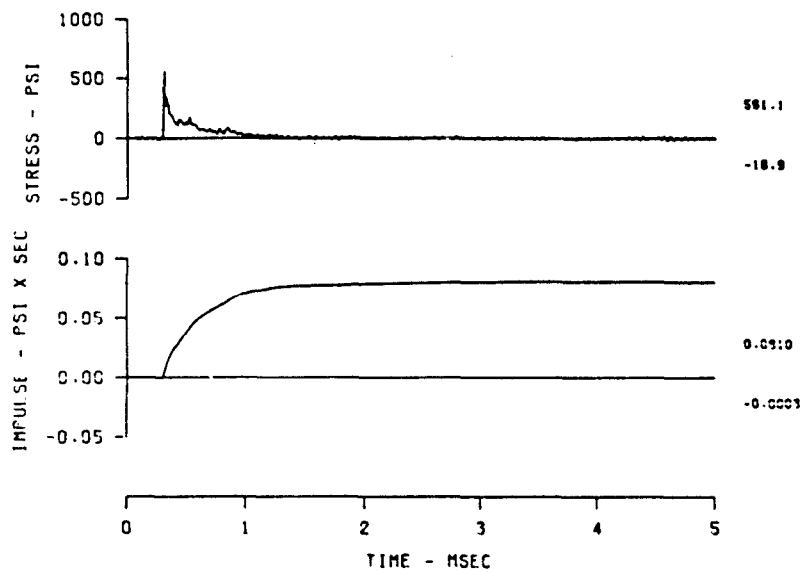
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AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



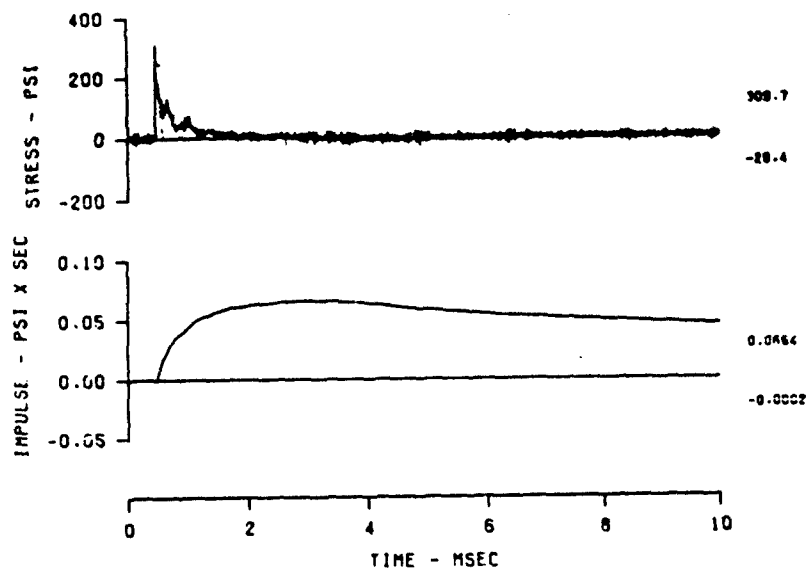
SHOT 28 CH 6 5
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



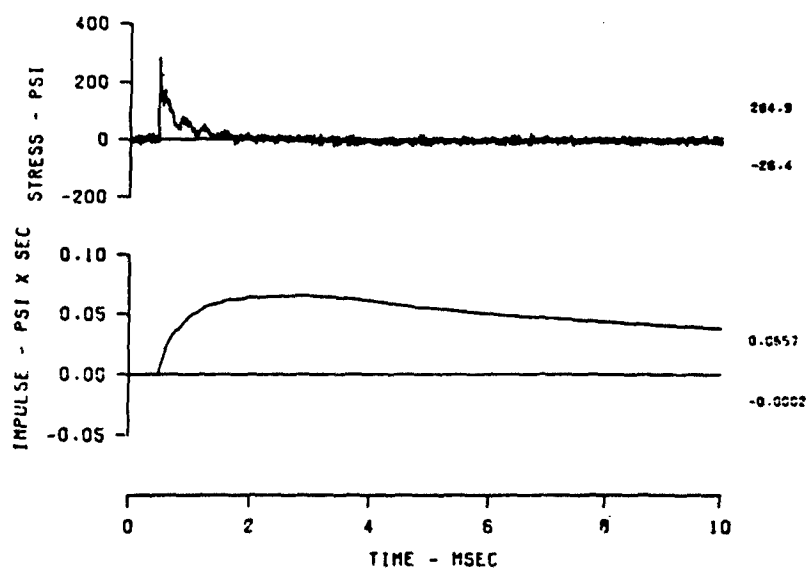
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AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



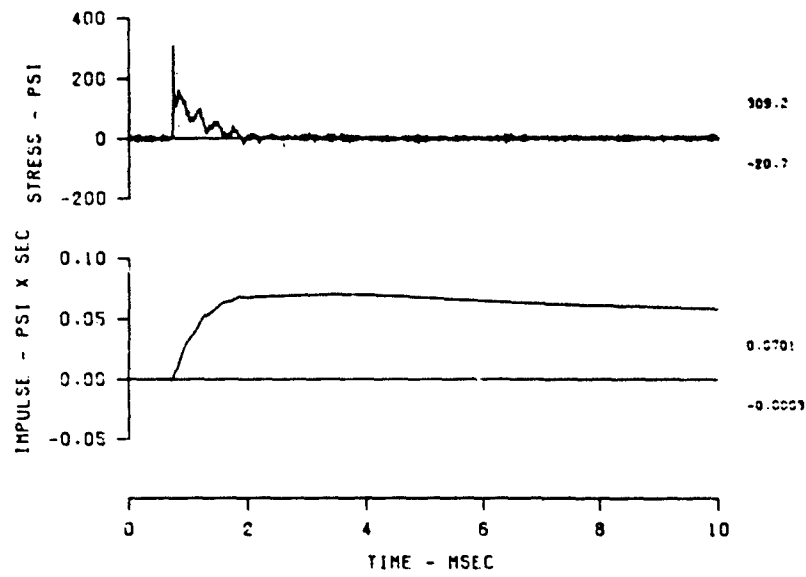
SHOT 28 CH 8 7
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



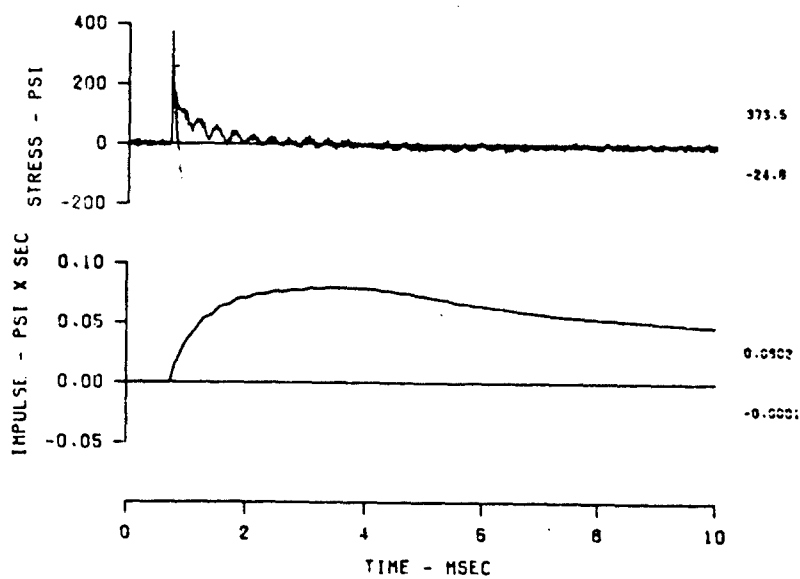
SHOT 28 CH 3 8
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



SHOT 28 CH 10 9
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

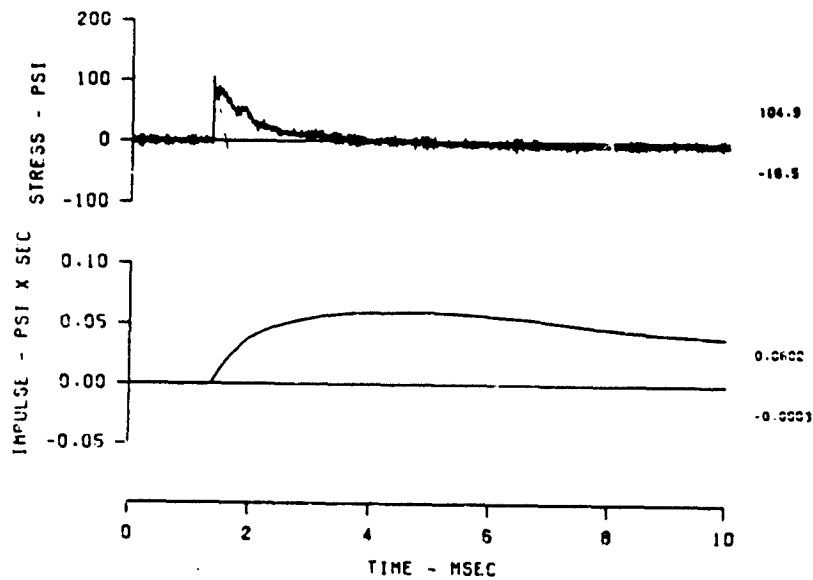


SHOT 28 CH 11 10
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

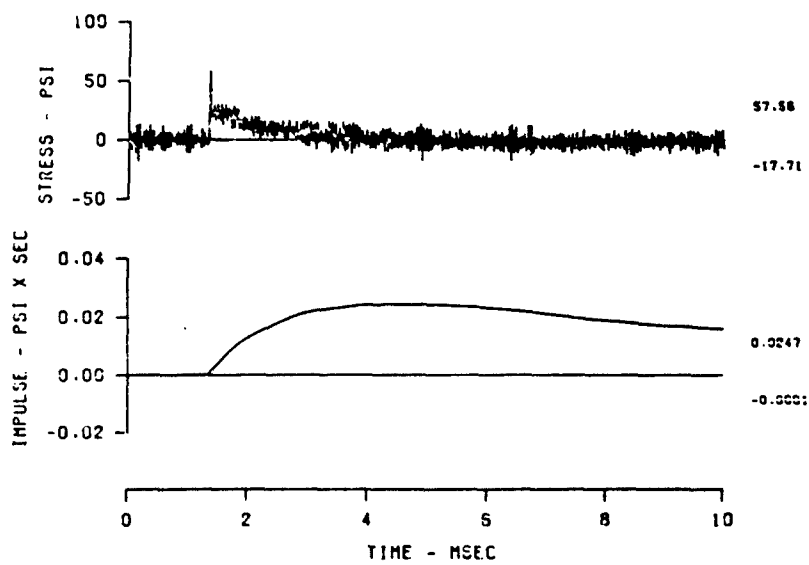


A231

SHOT 28 CH 12 11
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500000.HZ 02/27/84

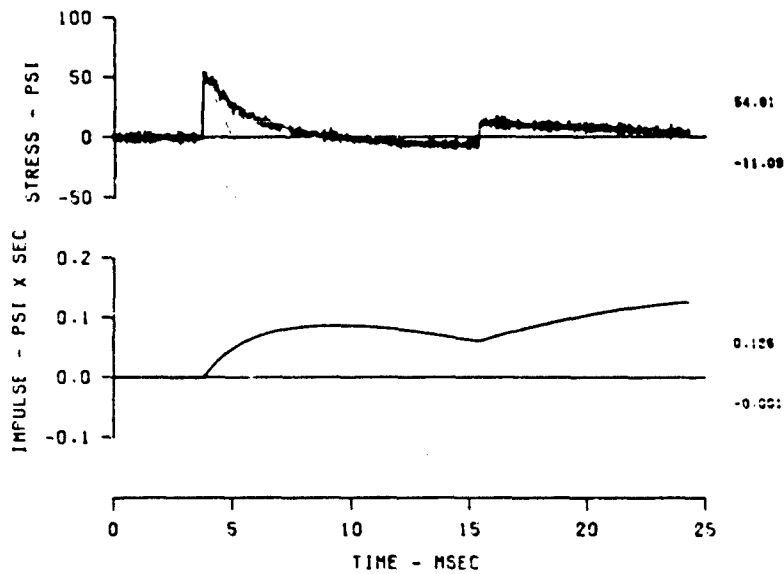


SHOT 28 CH 13 12
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

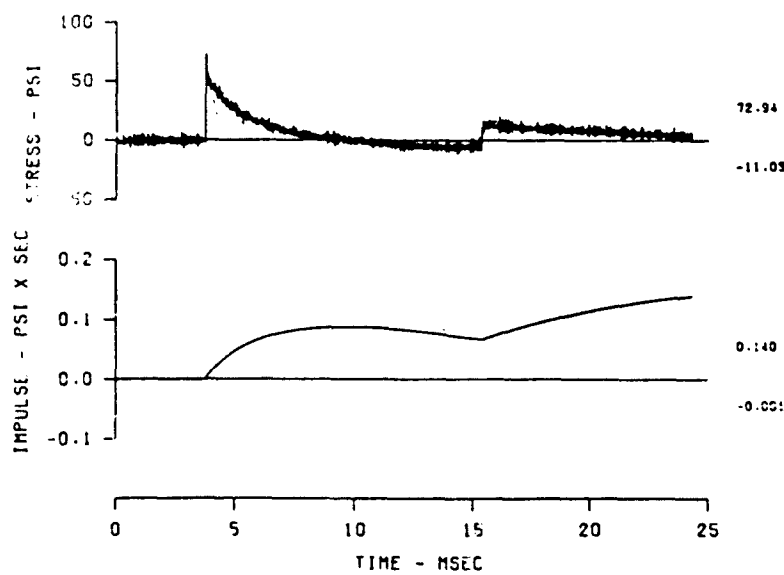


A232

SHOT 28 CH 14 13
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

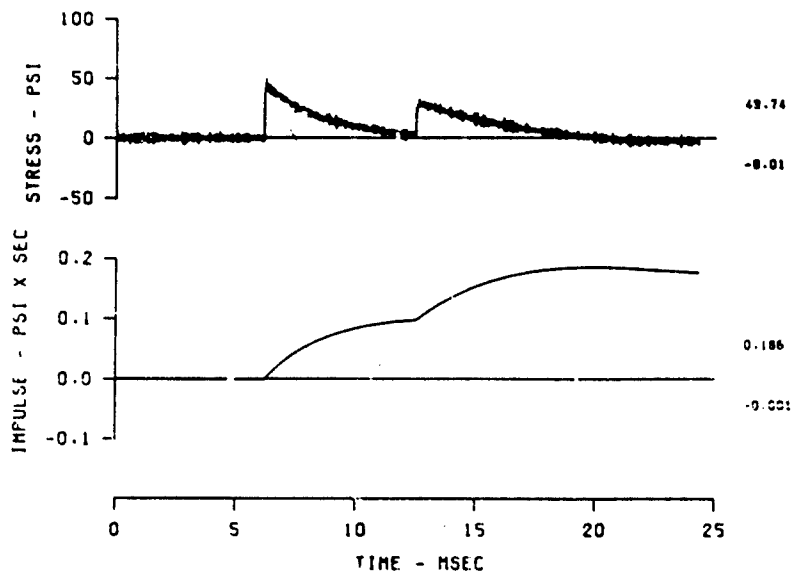


SHOT 28 CH 15 14
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 500000.HZ 02/27/84

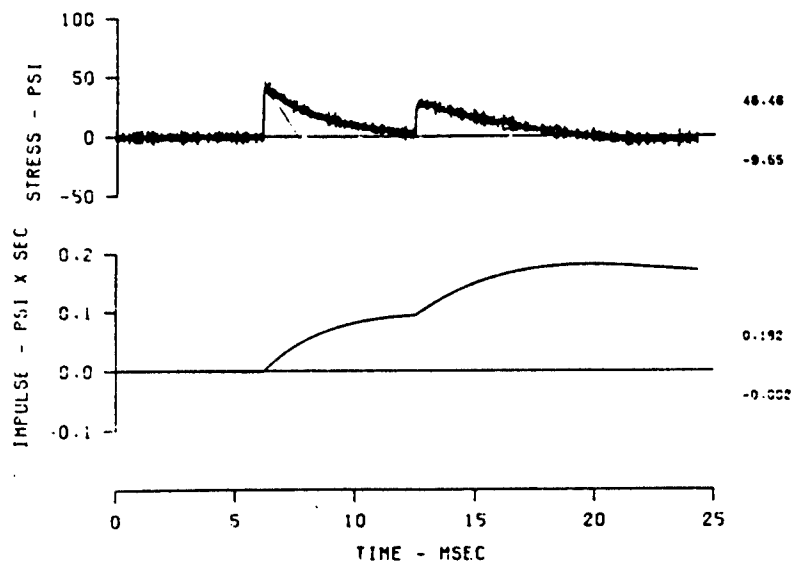


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SHOT 28 CH 16 15
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

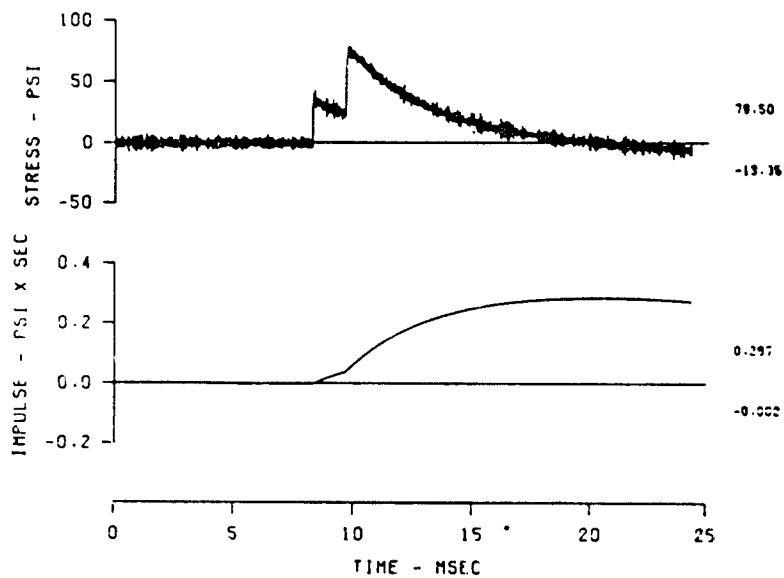


SHOT 28 CH 17 16
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 500000.HZ 02/27/84

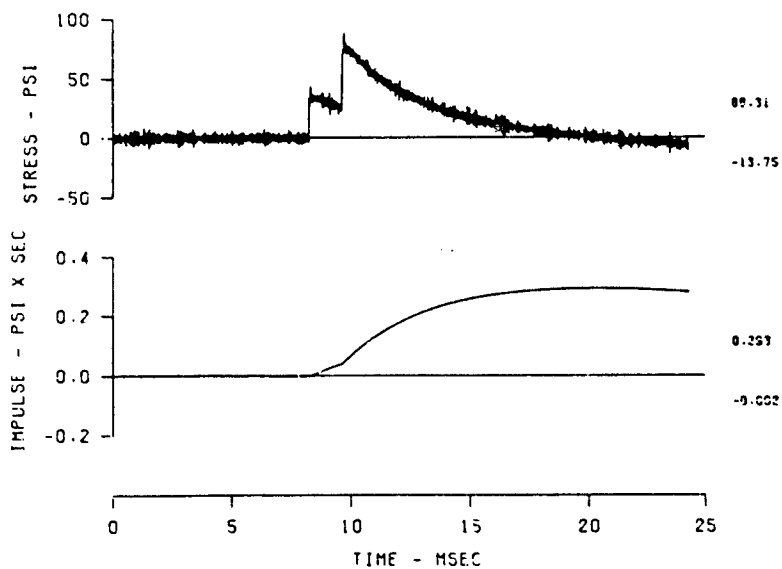


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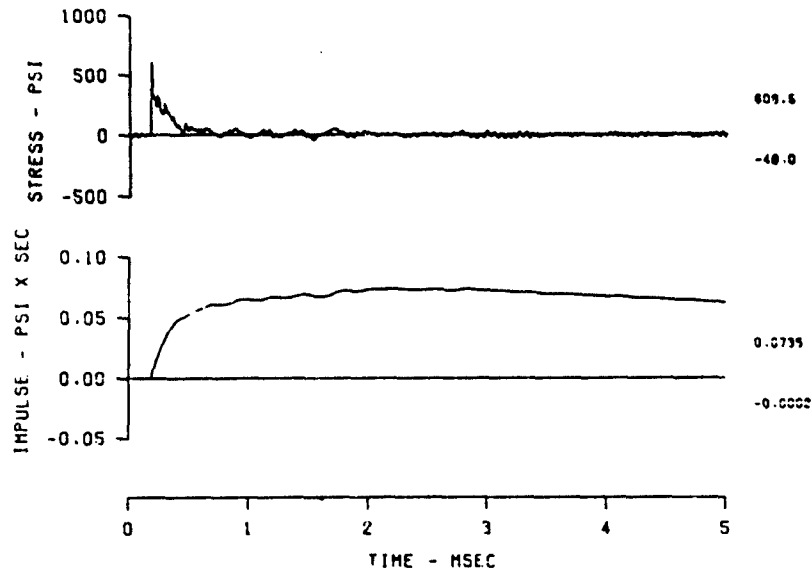
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500000.HZ 02/27/84



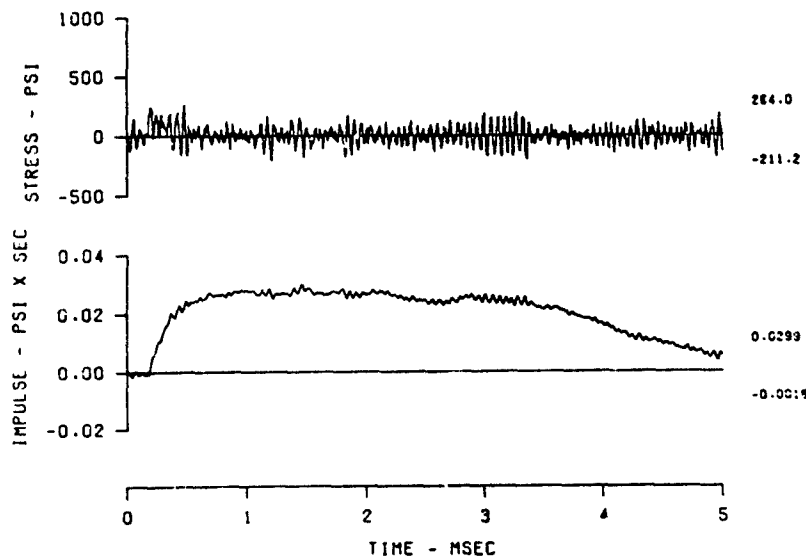
SHOT 28 CH 19 18
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



SHOT 29 CH 2 1
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

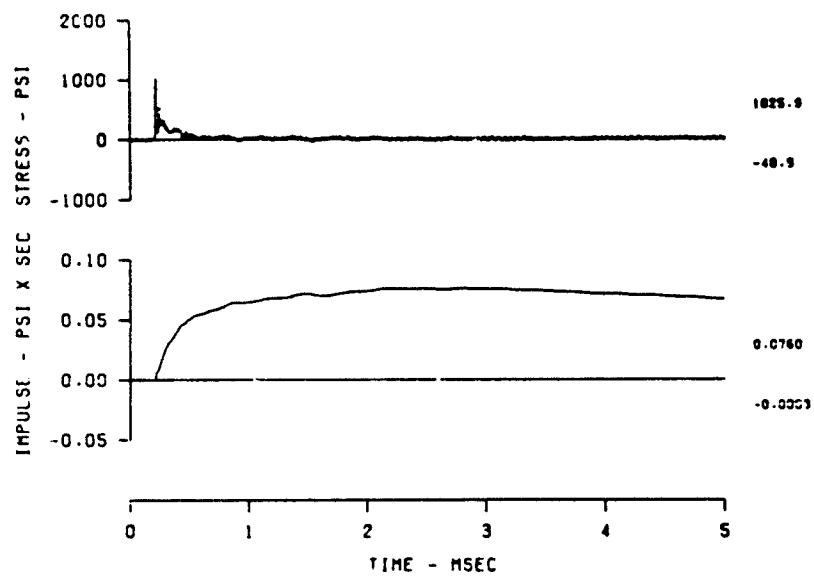


SHOT 29 CH 3 2
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500000.HZ 02/27/84

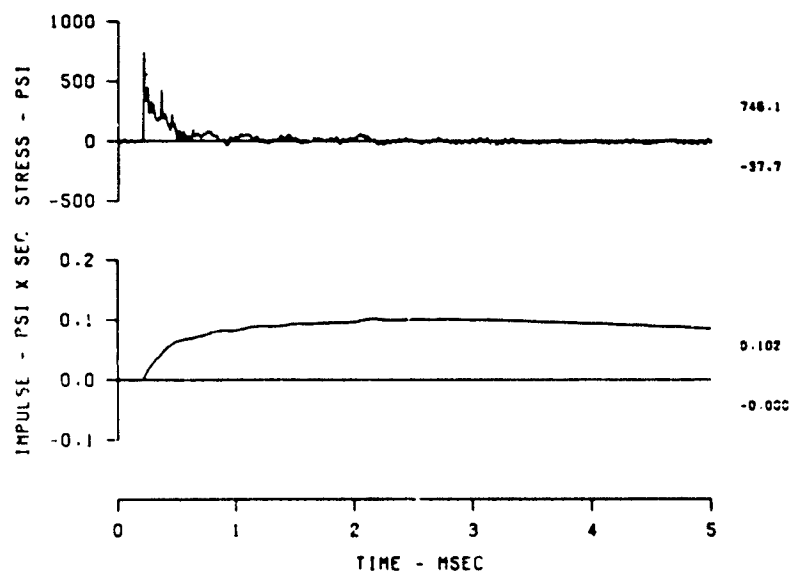


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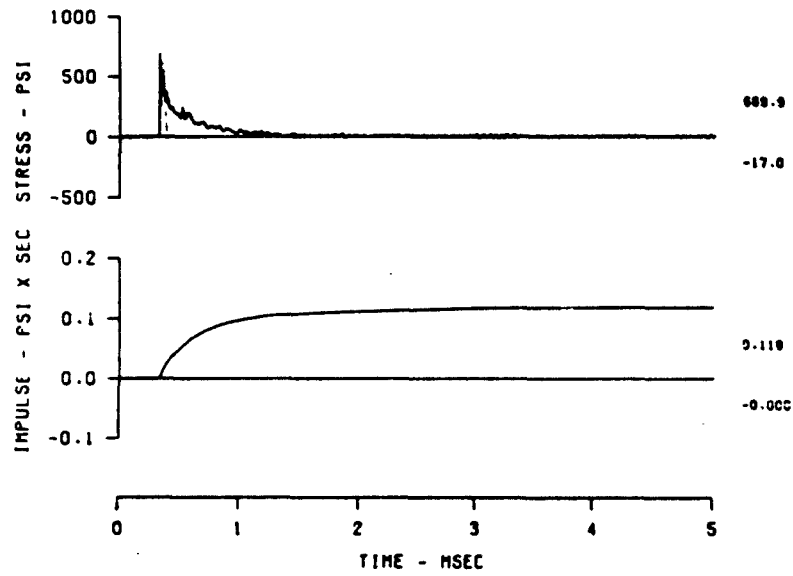
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AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



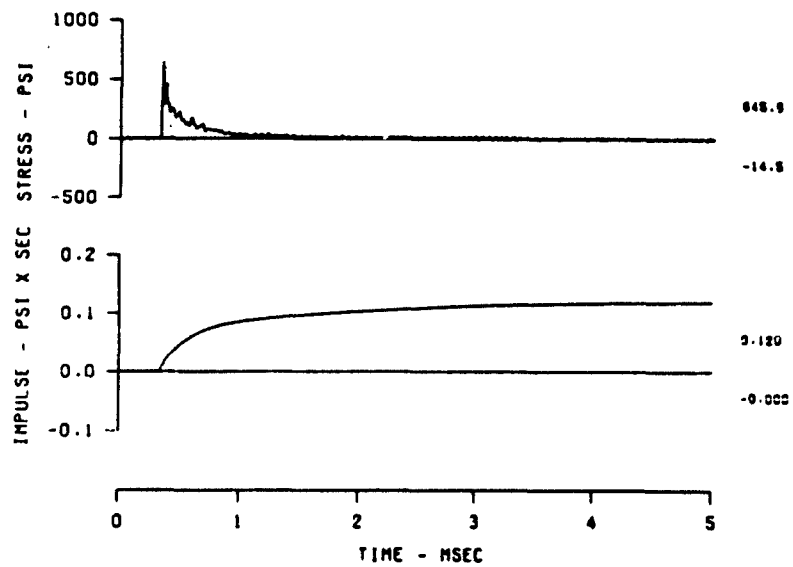
SHOT 29 CH 5 4
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



SHOT 29 CH 6 5
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500000.HZ 02/27/84

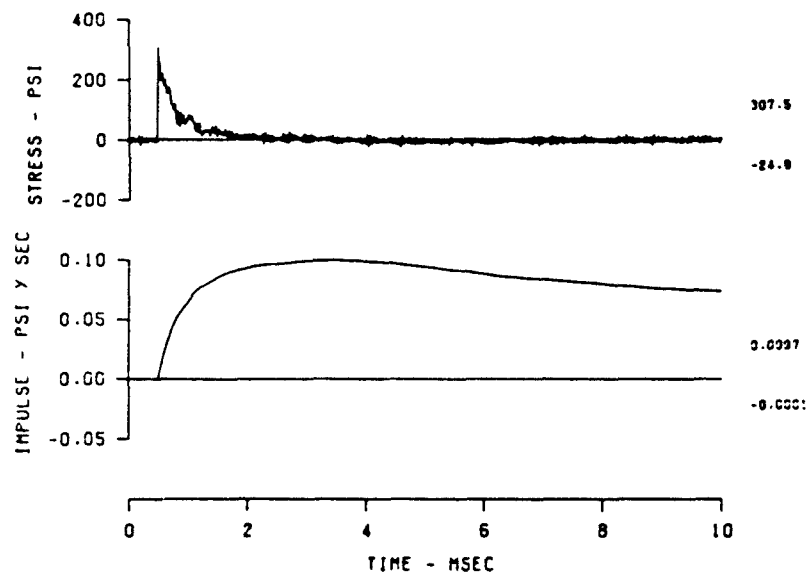


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500000.HZ 02/27/84

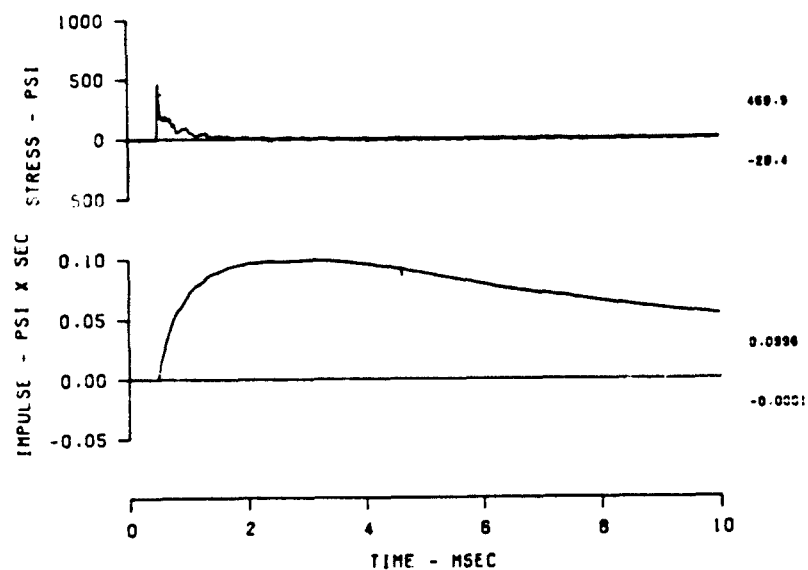


A238

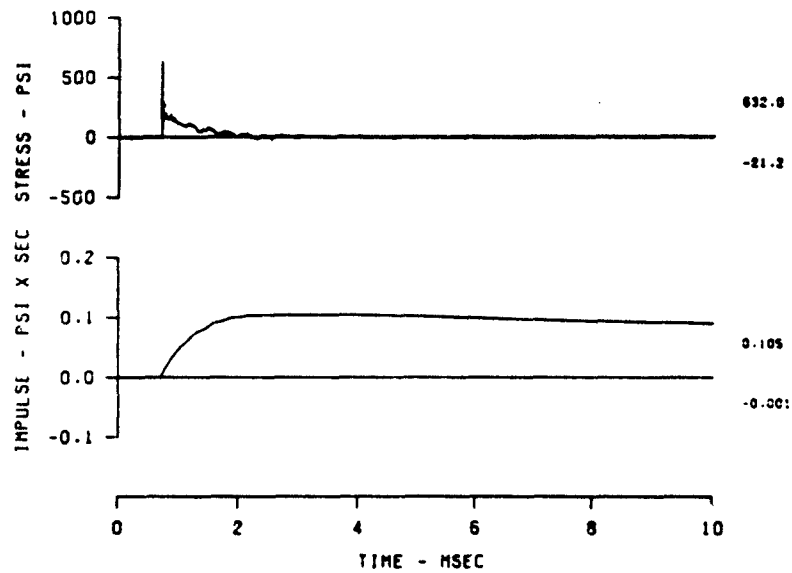
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500000.HZ 02/27/84



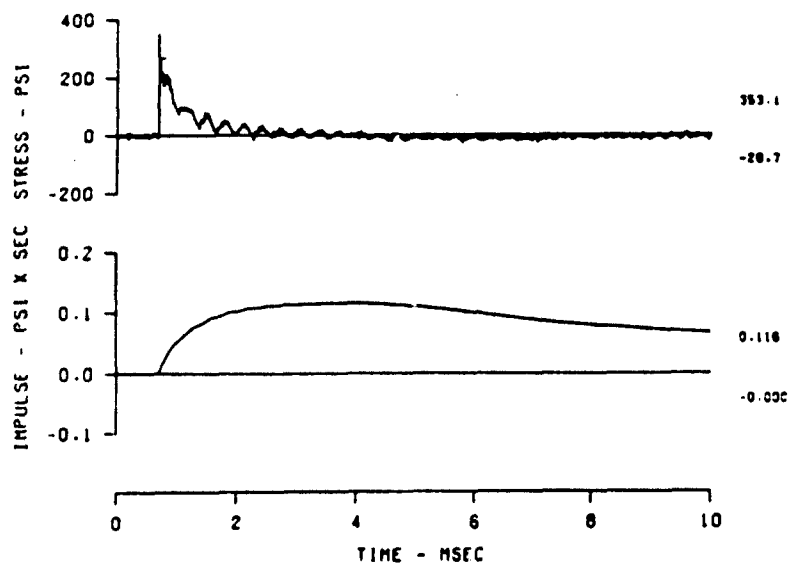
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500000.HZ 02/27/84



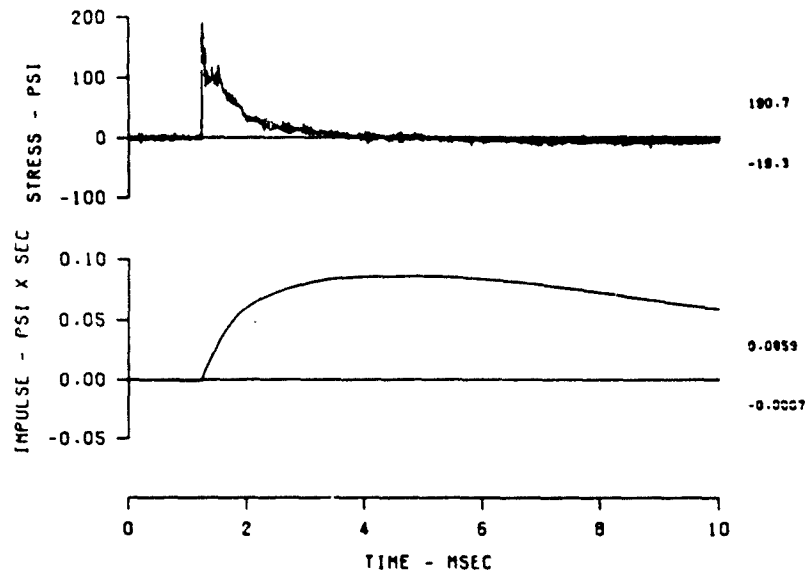
SHOT 29 CH 10 9
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



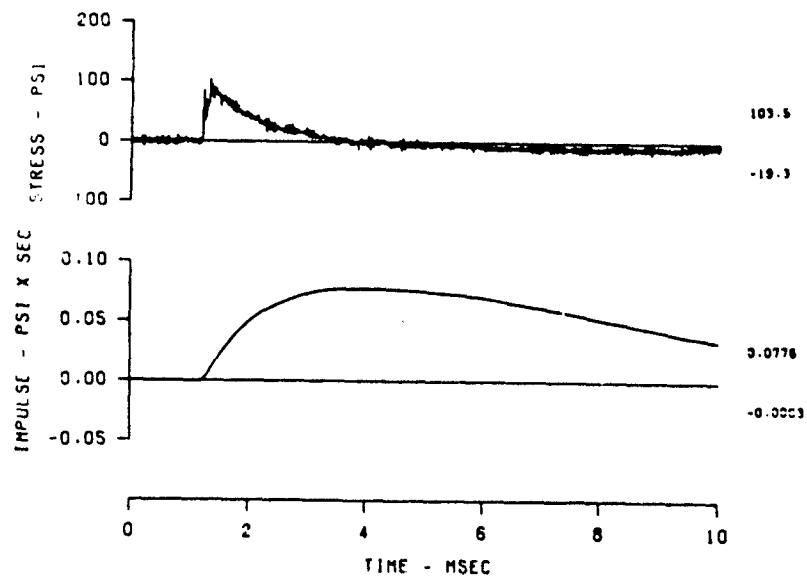
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AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



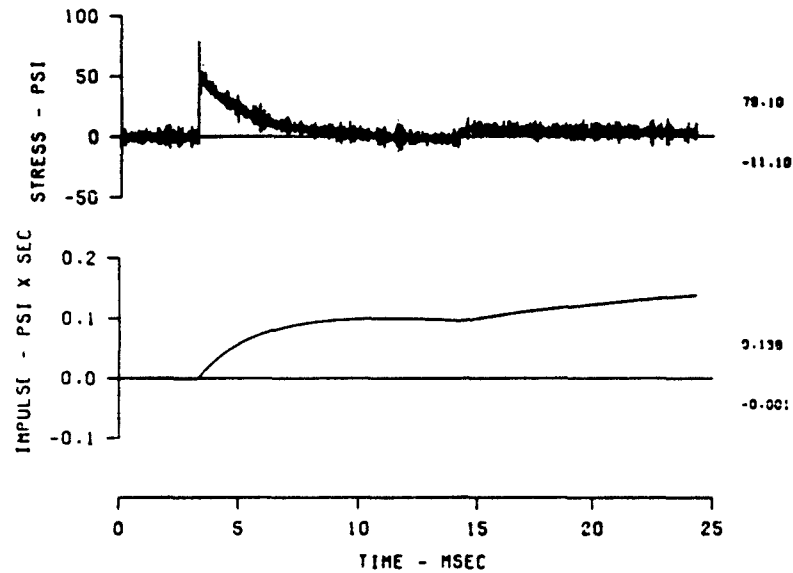
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 500000.HZ 02/27/84



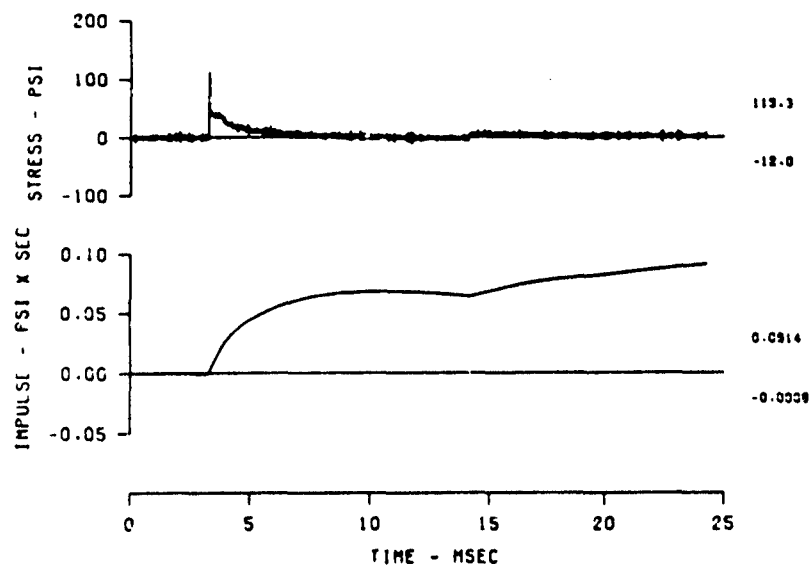
SHOT 29 CH 13 12
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



SHOT 29 CH 14 13
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84

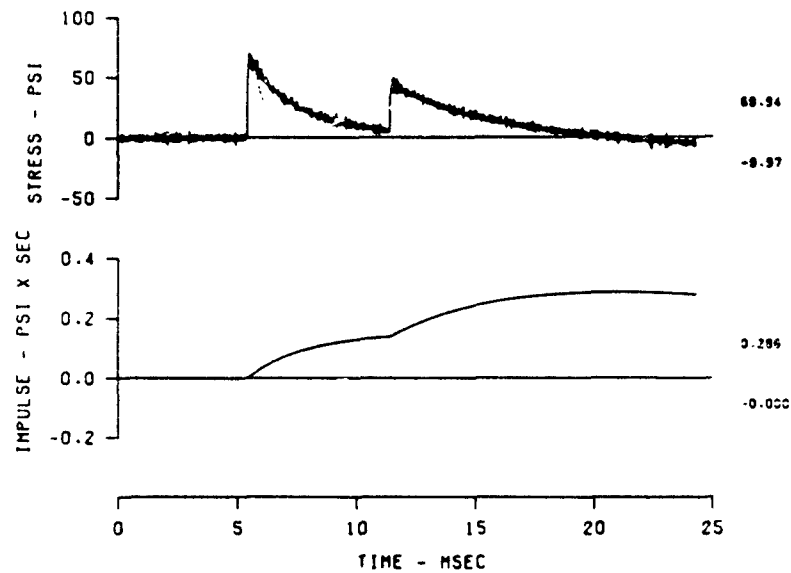


SHOT 29 CH 15 14
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 500000.HZ 02/27/84

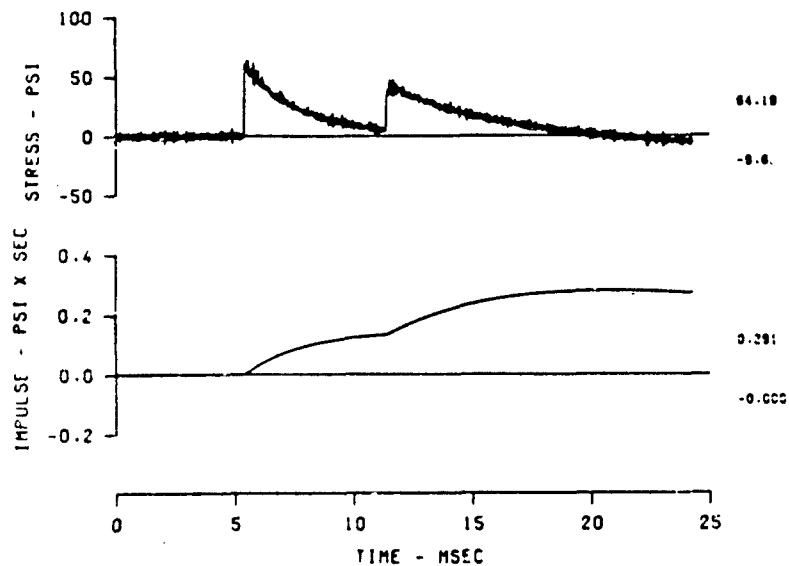


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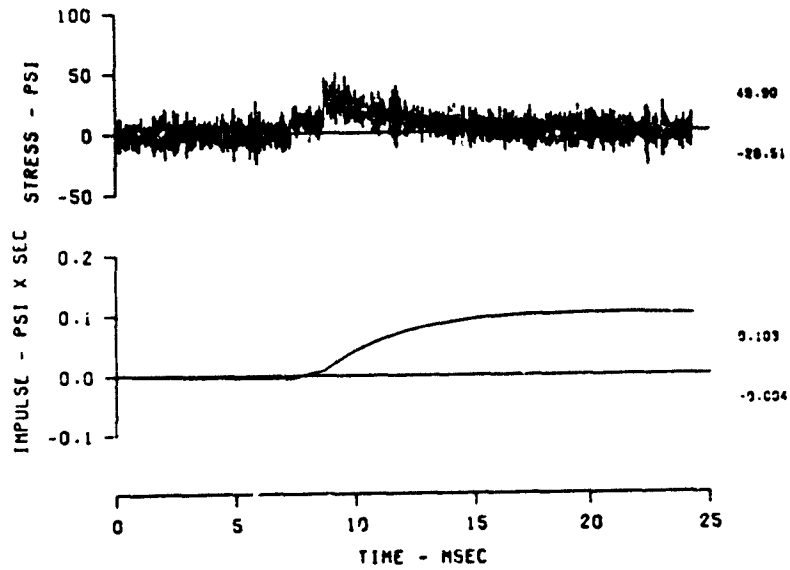
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500000.HZ 02/27/84



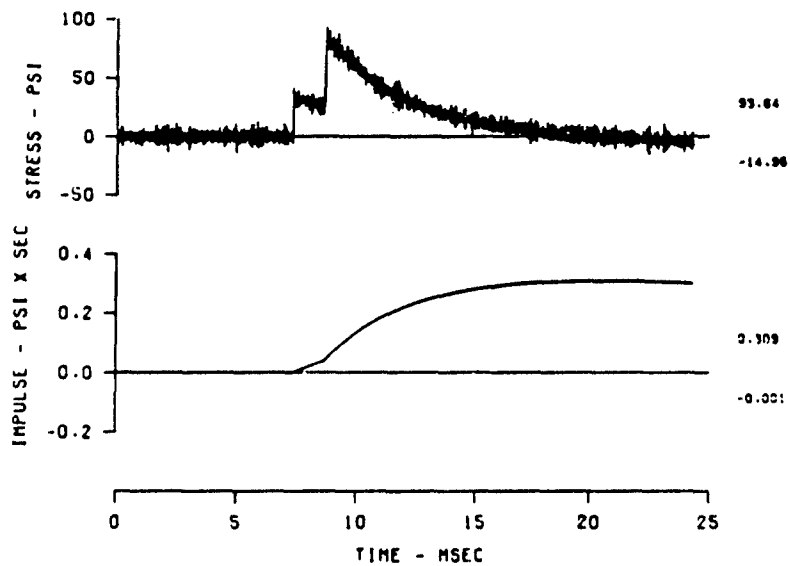
SHOT 29 CH 17 16
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



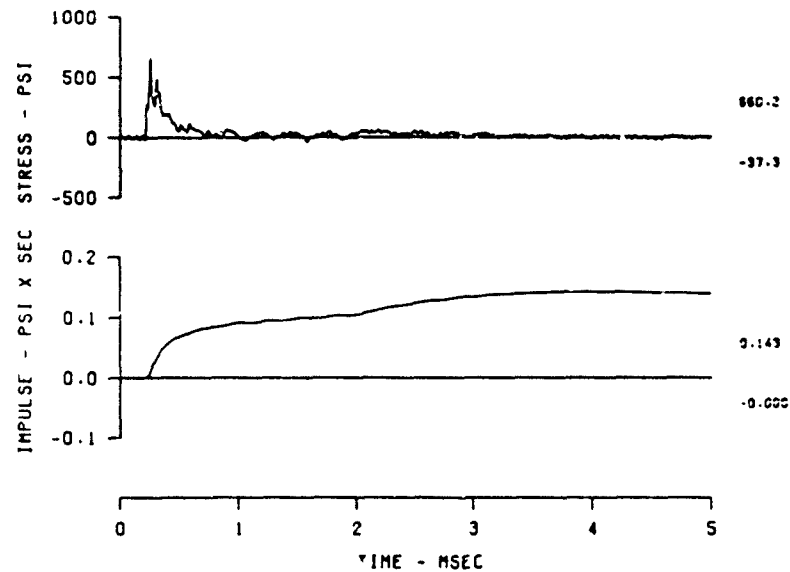
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 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



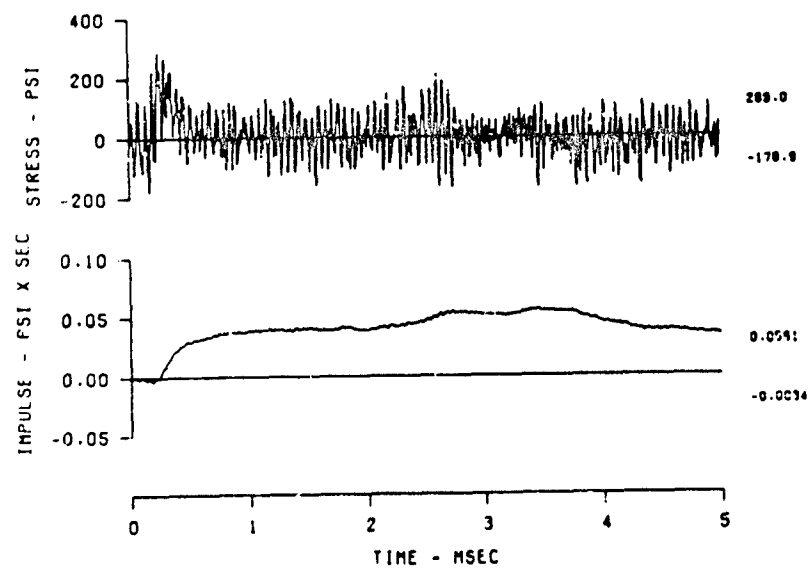
SHOT 29 CH 19 18
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



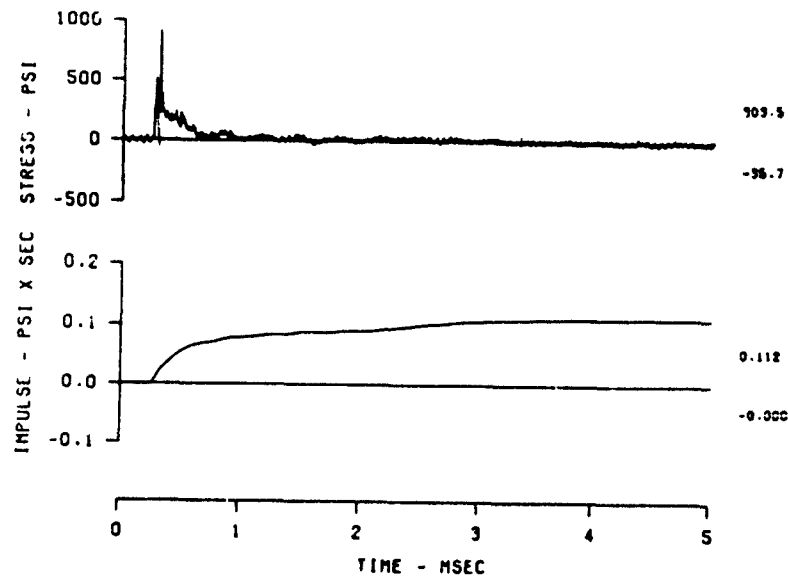
SHOT 30 CH 2 1
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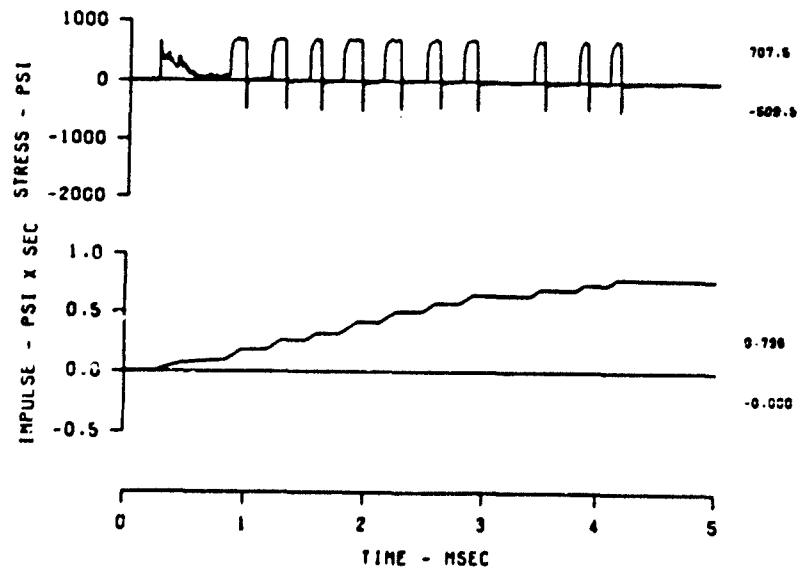
SHOT 30 CH 3 2
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 500000.HZ 02/27/84



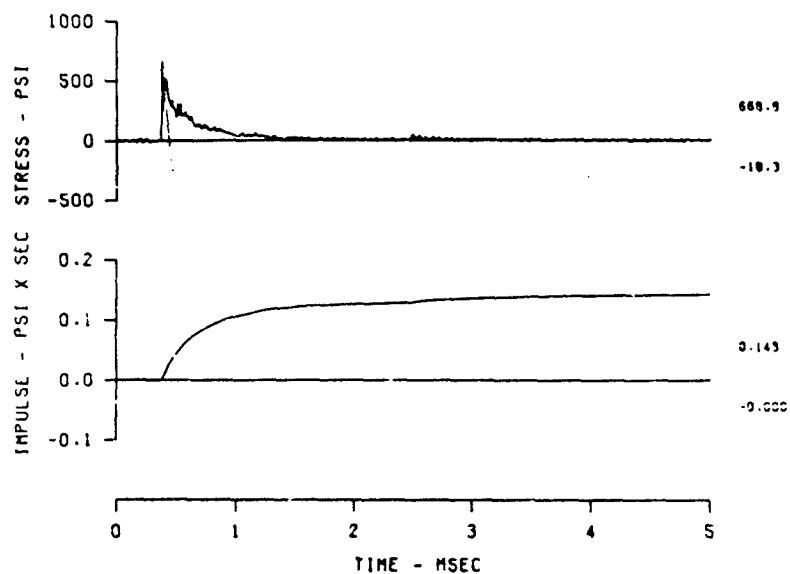
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500000.HZ 02/27/84



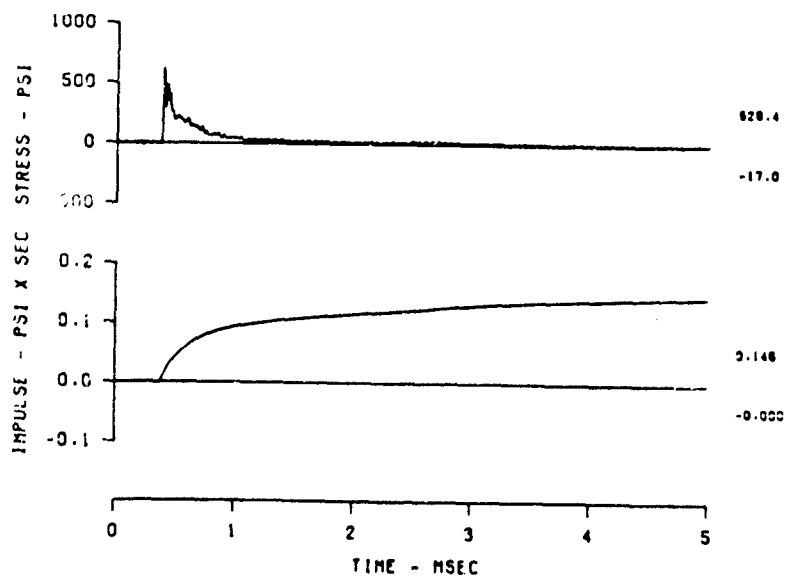
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500000.HZ 02/27/84



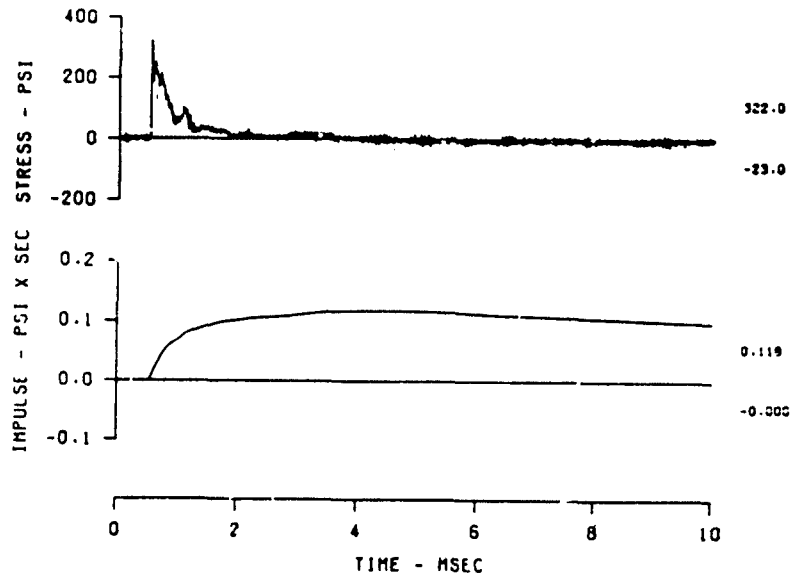
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500000.HZ 02/27/84



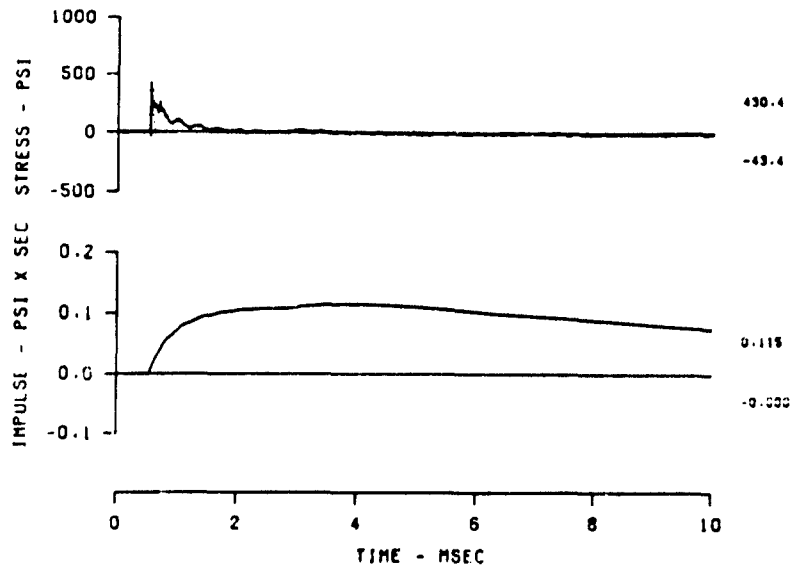
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500000.HZ 02/27/84



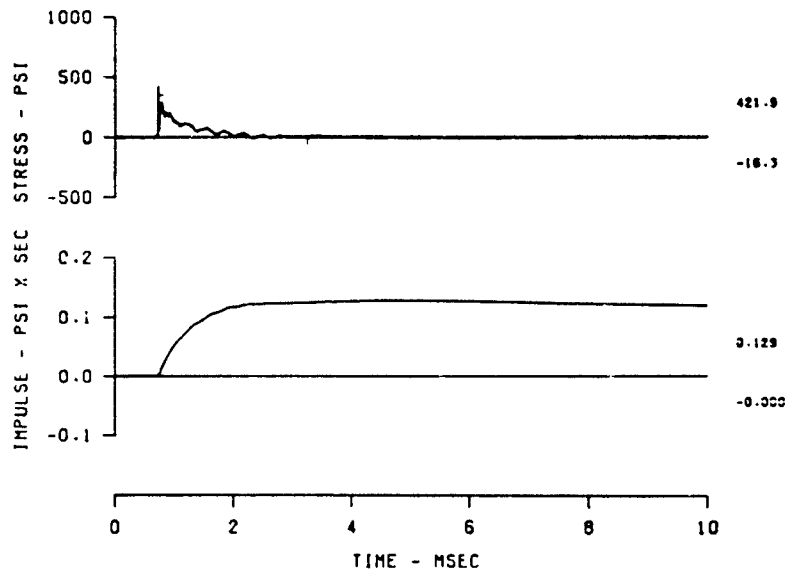
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500000.HZ 02/27/84



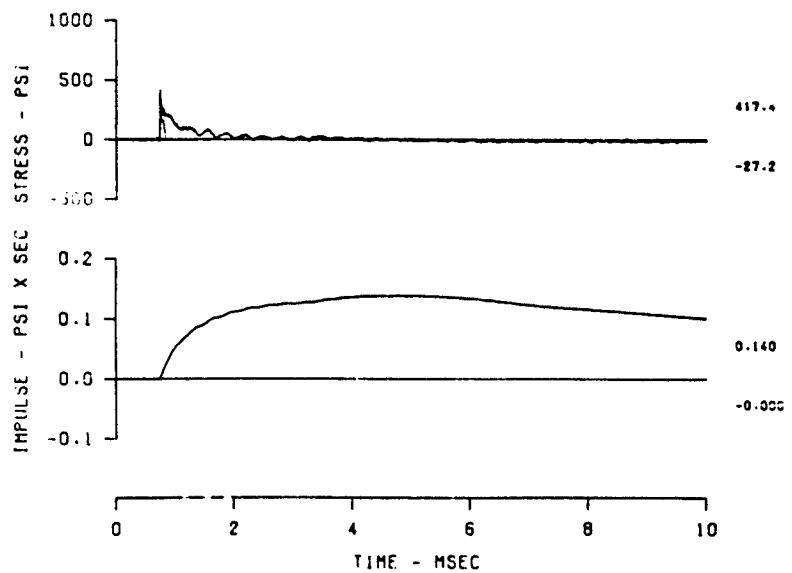
SHOT 30 CH 9 8
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500000.HZ 02/27/84



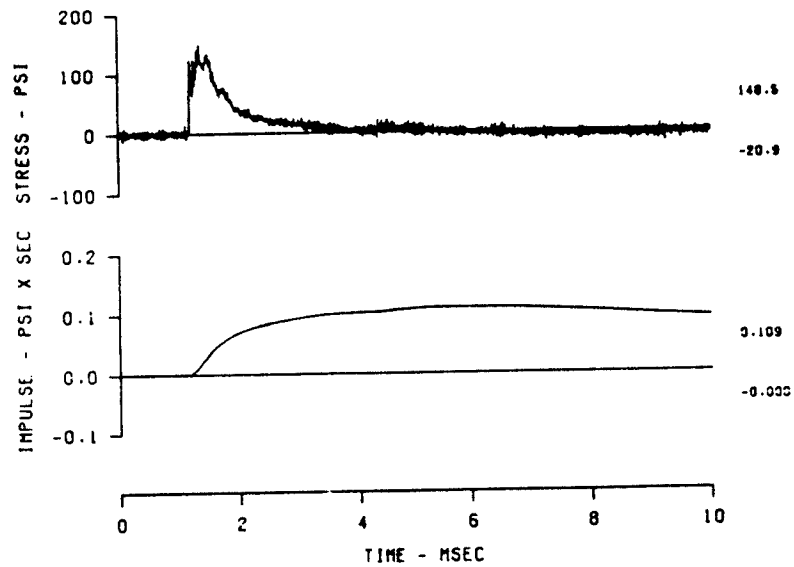
SHOT 30 CH 10 9
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



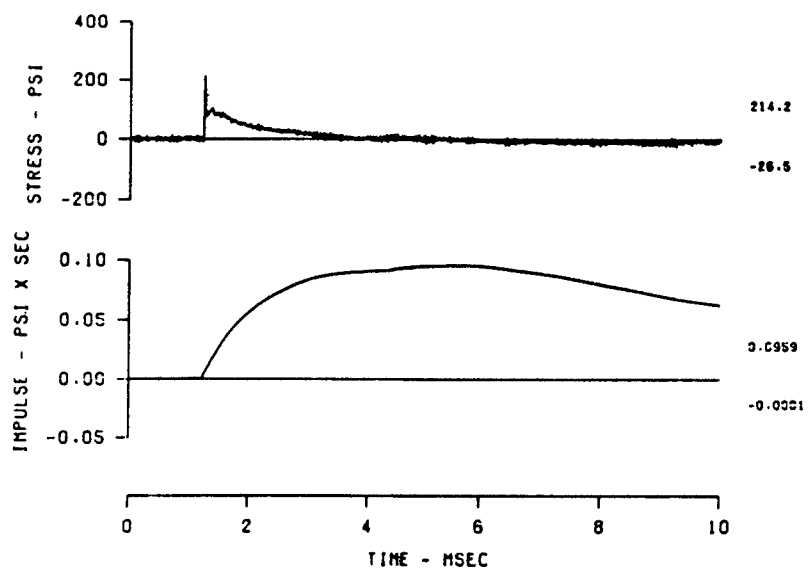
SHOT 30 CH 11 10
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



SHOT 30 CH 12 11
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

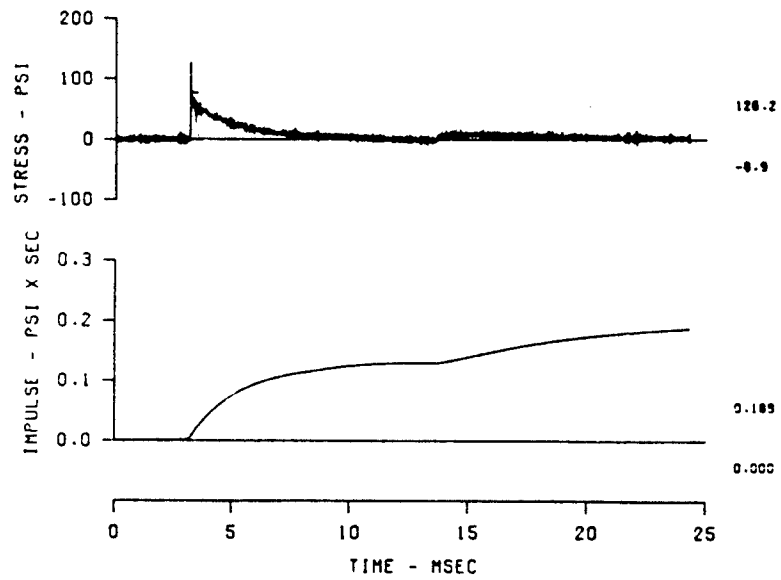


SHOT 30 CH 13 12
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500000.HZ 02/27/84

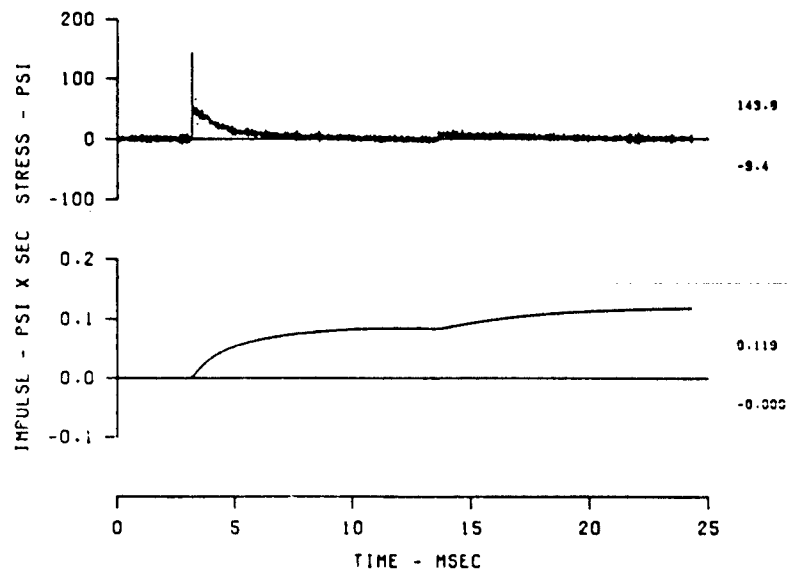


A250

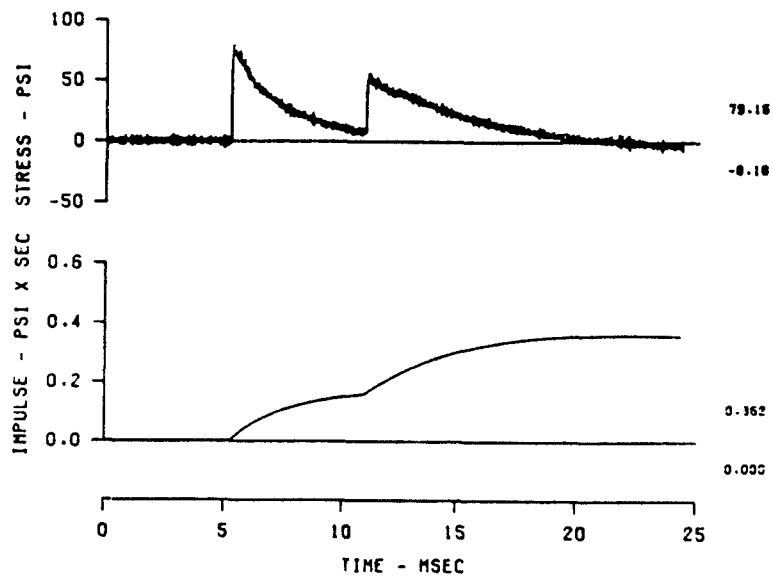
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500000.HZ 02/27/84



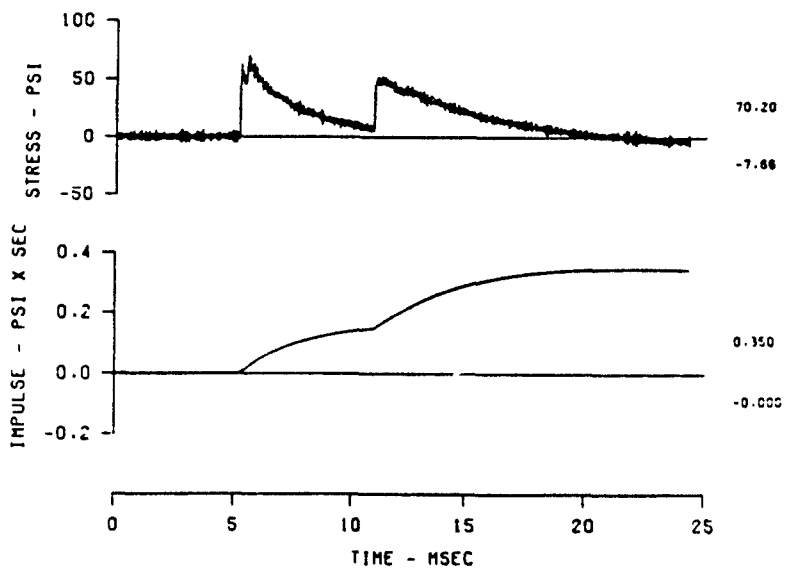
SHOT 30 CH 15 14
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84



SHOT 30 CH 16 15
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

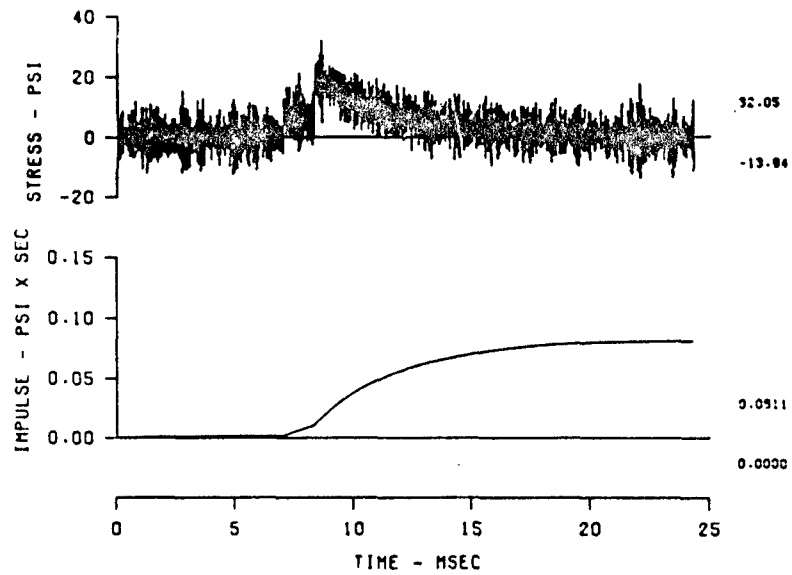


SHOT 30 CH 17 16
AIRBLAST PENETRATION 1983 6 INCH SQUA
500000.HZ 02/27/84

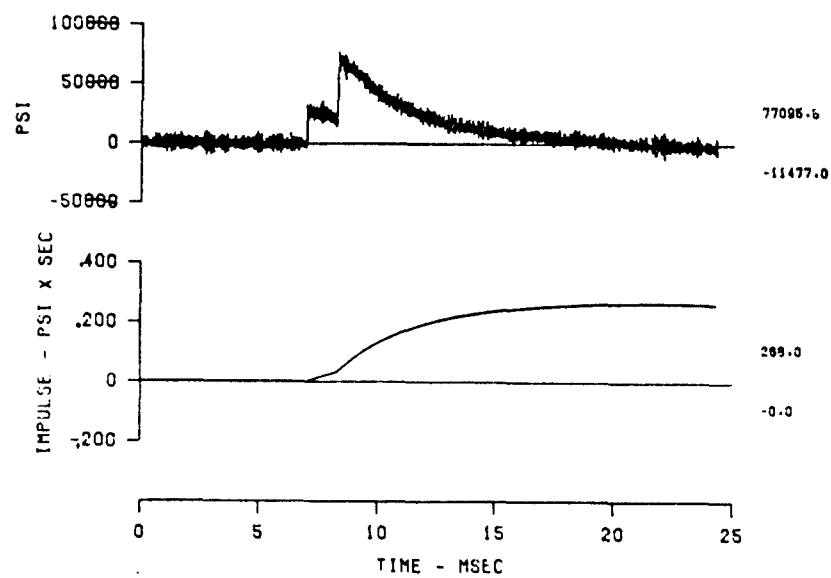


A252

SHOT 30 CH 18 17
 AIRBLAST PENETRATION 1983 6 INCH SQUA
 500000.HZ 02/27/84



SHOT 30 CH 19 18
 AIRBLAST PENETRATION 1983 6 INCH SQUARE T
 500000.HZ 03/13/84



APPENDIX B

TABULATED AIRBLAST

PEAK VALUES

- Airblast Penetration 1983 -

Shot 1

26-JUN-84 12:36:39

gauge no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa) msec	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa) msec
1	0.17	0.07	0.72	5.69	0.67	--	--	--
2	0.20	0.06	0.84	1.39	0.12	--	--	--
3	0.32	0.10	1.08	2.41	0.74	--	--	--
4	0.36	0.10	1.78	3.31	0.91	--	--	--
5	0.53	0.10	1.38	3.45	0.81	--	--	--
6	0.52	0.10	1.60	3.45	1.06	--	--	--
7	1.08	0.18	4.34	2.41	1.12	--	--	--
8	1.10	0.15	3.55	2.14	0.96	--	--	--
9	1.61	0.20	3.90	1.59	0.99	--	--	--
10	1.60	0.13	3.08	0.66	0.36	--	--	--
11	2.00	0.50	6.10	0.83	0.86	9.40	0.20	1.37
12	3.72	1.00	--	0.69	0.97	9.40	0.24	1.59
13	3.74	0.60	--	0.63	--	8.25	0.52	1.87
14	4.50	0.40	--	0.57	--	8.28	0.33	1.44
15	4.50	0.50	--	0.72	--	7.20	0.61	2.70
16	4.50	0.70	--	0.68	--	7.22	0.62	2.45
17	4.90	1.00	--	0.61	--	6.52	0.86	3.11
18	4.88	1.20	--	0.50	--	6.62	0.66	2.56

- Airblast Penetration 1983 -

Shot 2

26-JUN-84 12:53:32

gage no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa)	Imax (MPa)
1	0.30	0.08	0.97	3.41	0.50	---	---	---
2	0.27	0.07	1.00	0.61	---	---	---	---
3	0.50	0.08	1.44	3.31	0.62	---	---	---
4	0.40	0.10	1.60	1.50	0.62	---	---	---
5	0.69	0.08	1.25	3.03	0.61	---	---	---
6	0.62	0.16	1.53	1.67	0.75	---	---	---
7	1.32	0.20	1.32	1.66	0.88	---	---	---
8	1.36	0.12	3.60	1.79	0.66	---	---	---
9	1.95	0.15	2.82	1.26	0.70	---	---	---
10	3.42	0.16	2.38	0.37	0.18	---	---	---
11	3.45	0.50	3.00	0.71	0.66	---	---	---
12	4.45	---	---	0.40	---	---	---	0.99
13	---	0.62	---	0.46	10.72	0.19	1.19	1.34
14	---	---	---	---	10.80	0.17	---	---
15	5.30	---	---	---	9.46	0.26	---	---
16	5.40	0.65	---	0.52	---	---	2.04	---
17	5.80	0.45	---	0.55	8.40	0.45	1.79	---
18	5.80	---	---	0.30	8.35	0.62	2.21	---
		---	---	0.31	7.70	0.41	1.64	---

- Airblast Penetration 1983 -

Shot 3

26-JUN-84 13:02:10

sage no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa- msec)	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa- msec)
1	0.15	0.08	3.05	4.83	0.50	--	--	--
2	--	--	--	--	--	--	--	--
3	0.31	0.06	2.35	3.61	0.74	--	--	--
4	0.28	--	2.52	3.80	0.74	--	--	--
5	0.53	0.07	2.93	4.99	0.79	--	--	--
6	0.46	0.07	2.56	3.28	0.90	--	--	--
7	1.08	0.20	4.40	1.97	1.19	--	--	--
8	1.12	0.07	3.42	2.81	0.77	--	--	--
9	1.70	0.08	3.12	2.76	0.77	--	--	--
10	1.68	0.10	4.20	1.28	0.75	--	--	--
11	3.10	0.58	6.15	0.74	0.98	10.20	0.25	1.51
12	3.06	0.42	6.10	0.71	0.98	10.20	0.24	1.51
13	4.06	0.45	--	0.32	--	9.00	0.19	2.07
14	4.10	0.40	--	0.83	--	9.00	0.34	2.10
15	4.95	--	--	0.52	--	7.92	0.59	2.57
16	4.97	--	--	0.47	--	7.90	0.52	2.49
17	5.40	--	--	0.45	--	7.25	0.69	2.93
18	5.42	--	--	0.43	--	7.27	0.66	2.88

- Airblast Penetration 1983 -

Shot 4

26-JUN-84 13:14:47

gage no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, T00 (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa- msec)	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa- msec)
1	0.22	0.06	1.01	2.32	0.32	--	--	--
2	0.25	0.08	0.96	2.37	0.38	--	--	--
3	0.46	0.06	1.40	1.48	0.36	--	--	--
4	0.47	0.12	1.62	1.59	0.38	--	--	--
5	0.75	0.06	1.60	1.79	0.30	--	--	--
6	0.74	0.06	1.38	1.72	0.46	--	--	--
7	1.52	0.16	2.70	1.14	0.64	--	--	--
8	1.50	0.22	2.90	0.83	0.41	--	--	--
9	2.32	0.18	2.30	0.72	0.37	--	--	--
10	2.30	0.18	2.68	0.79	0.46	--	--	--
11	4.06	1.20	5.18	0.38	0.59	12.20	0.31	0.76
12	4.04	0.70	5.00	0.43	0.60	12.20	0.31	0.79
13	5.25	1.00	5.50	0.32	0.61	10.70	0.21	1.06
14	5.26	1.00	5.50	0.37	0.65	10.80	0.21	1.17
15	--	--	--	--	--	--	--	--
16	--	--	--	--	--	--	--	--
17	6.05	--	--	0.28	--	8.86	0.30	1.69
18	6.82	--	--	0.26	--	8.85	0.34	1.67

- Airblast Penetration 1983 -

Shot 5

26-JUN-84 13:26:41

gauge no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	arriv. time, Ta (msec)	Pmax (MPa)	I max (MPa)	msec
1	0.21	--	2.07	1.86	--	--	--	--
2	0.27	0.07	2.00	9.59	--	--	--	--
3	0.55	--	1.75	1.75	--	--	--	--
4	0.43	0.07	1.55	1.90	--	--	--	--
5	0.84	0.08	1.50	2.07	--	--	--	--
6	0.76	0.09	2.18	1.09	--	--	--	--
7	1.76	0.15	2.40	0.62	--	--	--	--
8	1.78	0.14	2.07	0.76	--	--	--	--
9	1.75	0.14	2.30	0.65	--	--	--	--
10	2.72	--	2.30	0.46	--	--	--	--
11	4.00	1.22	4.52	0.27	13.80	0.10	0.49	0.49
12	4.78	0.80	4.78	0.28	13.84	0.11	0.54	0.54
13	6.16	1.55	5.50	0.21	12.22	0.12	0.65	0.65
14	6.20	1.10	5.50	0.26	12.25	0.13	0.70	0.70
15	7.40	1.76	--	0.19	10.96	0.19	0.88	0.88
16	7.38	1.50	--	0.19	10.90	0.19	0.87	0.87
17	8.00	--	--	0.18	10.15	0.22	0.97	0.97
18	8.00	--	--	0.18	10.20	0.23	0.93	0.93

- Airblast Penetration 1983 -

Shot 6

26-JUN-84 13:33:25

sage no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	arriv. time, Ta (msec)	Pmax (MPa)	I max (MPa)	I max (MPa)
1	0.28	--	1.82	2.88	0.25	--	--	--
2	0.31	0.05	1.93	5.52	0.42	--	--	--
3	0.62	0.08	1.88	3.46	0.24	--	--	--
4	0.50	0.08	1.42	1.56	0.23	--	--	--
5	0.90	0.05	1.50	2.93	0.21	--	--	--
6	0.84	0.10	1.88	1.31	0.26	--	--	--
7	1.85	0.20	2.60	0.92	0.38	--	--	--
8	1.88	0.16	2.50	0.83	0.26	--	--	--
9	2.88	0.15	2.50	0.66	0.14	--	--	--
10	2.88	--	2.65	0.43	0.28	--	--	--
11	5.95	1.12	4.95	0.48	0.70	0.19	0.87	0.87
12	5.95	1.30	5.00	0.26	0.37	0.12	0.47	0.60
13	7.35	1.50	5.70	0.19	0.37	0.12	0.60	0.64
14	7.40	0.09	5.55	0.24	0.39	0.14	0.85	0.85
15	--	1.00	--	0.21	--	0.18	0.85	0.83
16	--	1.35	--	0.19	--	0.19	0.83	0.94
17	--	--	--	0.17	--	0.23	0.93	0.93
18	--	--	--	--	--	0.21	0.93	0.93

- Airblast Penetration 1983 -

Shot 7

26-JUN-84 14:13:12

stage no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa) msec	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa) msec
1	0.38	--	1.40	3.10	0.29	--	--	--
2	0.42	0.06	1.56	3.89	0.26	--	--	--
3	0.82	--	1.15	0.77	0.08	--	--	--
4	0.79	0.07	1.09	1.23	0.16	--	--	--
5	1.18	--	2.56	1.37	0.12	--	--	--
6	1.12	0.09	2.18	1.03	0.17	--	--	--
7	2.33	--	2.53	0.31	0.20	--	--	--
8	2.38	0.18	2.72	0.34	0.21	--	--	--
9	3.44	0.65	4.00	0.24	0.26	18.10	0.11	0.36
10	3.42	0.88	3.60	0.24	0.26	18.10	0.09	0.37
11	5.85	1.10	4.90	0.17	0.28	15.42	0.09	0.34
12	5.80	0.32	5.05	0.20	0.29	15.42	0.08	0.37
13	7.38	1.60	5.30	0.14	0.28	13.75	0.09	0.41
14	7.38	1.12	5.00	0.19	0.28	13.75	0.10	0.44
15	8.65	1.50	--	0.15	--	12.38	0.12	0.57
16	8.64	1.75	--	0.13	--	12.32	0.13	0.57
17	9.36	1.86	--	0.13	--	11.59	0.14	0.64
18	9.36	--	--	0.14	--	11.59	0.14	0.64

- Airblast Penetration 1983 -

Shot 8

26-JUN-84 14:20:03

Sage no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, T00 (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa- msec)	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa- msec)
1	0.36	--	1.11	2.59	0.35	--	--	--
2	0.45	--	--	4.14	--	--	--	--
3	0.84	--	1.55	1.37	0.19	--	--	--
4	0.73	0.09	1.04	1.12	0.21	--	--	--
5	1.22	--	2.00	1.47	0.12	--	--	--
6	1.18	1.10	0.75	0.68	0.17	--	--	--
7	2.39	--	2.30	0.33	0.21	--	--	--
8	2.40	0.21	2.50	0.41	0.22	--	--	--
9	3.46	0.90	3.05	0.28	0.26	17.67	0.10	0.37
10	3.43	0.60	3.20	0.20	0.20	17.63	0.10	0.41
11	5.72	1.30	4.08	0.18	0.20	15.00	0.12	0.37
12	5.70	1.12	4.20	0.20	0.29	15.05	0.08	0.39
13	7.25	1.52	4.72	0.17	0.29	13.40	0.10	0.45
14	7.23	1.62	4.65	0.20	0.30	13.42	0.10	0.47
15	8.50	1.95	--	0.16	--	12.10	0.14	0.61
16	8.50	1.75	--	0.15	--	12.05	0.14	0.59
17	9.15	1.78	--	0.14	--	11.35	0.17	0.69
18	9.12	1.90	--	0.14	--	11.35	0.14	0.68

- Airblast Penetration 1983 -

Shot 9

26-JUN-84 14:26:56

gage no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa)	Imax (msec)
1	0.28	0.89	0.94	4.97	6.43	---	---	---
2	0.23	0.88	0.93	3.17	0.32	---	---	---
3	0.47	0.86	0.75	2.87	0.26	---	---	---
4	0.48	0.84	1.07	2.81	0.27	---	---	---
5	0.78	0.12	2.35	1.15	0.16	---	---	---
6	0.76	0.10	1.98	1.55	0.30	---	---	---
7	1.68	0.65	2.45	0.59	0.28	---	---	---
8	1.72	0.58	2.50	0.59	0.29	0.14	0.43	0.41
9	2.60	0.75	3.20	0.36	0.36	0.14	0.59	0.59
10	2.52	0.85	3.60	0.35	0.38	0.14	0.61	0.61
11	4.60	1.78	4.42	0.27	0.41	0.09	0.54	0.54
12	4.60	0.85	4.30	0.31	0.42	0.10	0.57	0.57
13	5.89	2.80	5.32	0.23	0.41	0.14	0.64	0.64
14	5.92	1.12	5.40	0.20	0.43	0.14	0.70	0.70
15	7.10	1.65	---	0.22	---	0.24	0.94	0.94
16	7.00	2.25	---	0.27	---	0.24	0.94	0.94
17	7.68	1.55	---	0.21	---	0.24	1.07	1.07
18	7.68	1.60	---	0.19	---	0.24	1.08	1.08

- Airblast Penetration 1983 -

Shot 10

26-JUN-84 14:33:31

gage no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa)	Imax (MPa)
1	0.40	0.07	1.18	4.90	0.93	0.17	0.70	0.68
2	0.48	0.08	1.03	2.97	0.57	0.12	0.68	0.96
3	0.63	0.06	1.28	2.41	0.59	0.16	0.99	1.35
4	0.72	0.10	1.33	2.69	0.55	0.19	1.48	1.77
5	0.88	0.06	---	2.21	0.46	0.24	1.74	1.97
6	0.94	0.13	2.30	2.12	0.67	0.34	1.74	1.94
7	1.72	0.31	2.88	2.66	0.50	0.41	1.97	1.94
8	1.71	0.20	2.90	0.81	0.54	0.41	1.97	1.94
9	2.40	0.78	3.08	0.52	0.61	0.41	1.97	1.94
10	2.50	0.82	3.18	0.52	0.63	0.41	1.97	1.94
11	4.21	0.70	5.18	0.45	0.68	0.41	1.97	1.94
12	4.20	0.92	6.88	0.42	0.69	0.41	1.97	1.94
13	5.38	1.06	7.55	0.32	---	---	---	---
14	5.40	1.12	---	0.40	---	---	---	---
15	6.40	1.30	---	0.38	---	---	---	---
16	6.36	1.38	---	0.31	---	---	---	---
17	6.89	1.72	---	0.31	---	---	---	---
18	6.90	2.20	---	0.20	---	---	---	---

- Airblast Penetration 1983 -

Shot 11

27-JUN-84 08:48:04

gage no.	-----First Pulse-----				-----Second Pulse-----			
	arriv. time, T _a (msec)	inter. time, T _o (msec)	pos. dur. (msec)	Pmax (MPa)	IMax (MPa) msec	arriv. time, T _a (msec)	Pmax (MPa)	IMax (MPa) msec
1	0.37	0.09	0.92	2.62	0.52	--	--	--
2	0.42	0.11	0.91	1.57	0.33	--	--	--
3	0.68	0.13	1.03	1.72	0.30	--	--	--
4	0.70	0.11	1.15	1.19	0.32	--	--	--
5	1.05	0.05	--	1.00	0.17	--	--	--
6	1.03	0.10	1.22	1.17	0.30	--	--	--
7	2.00	0.70	2.60	0.38	0.30	17.18	0.14	0.45
8	2.00	0.72	2.72	0.45	0.30	17.20	0.14	0.44
9	2.90	1.01	3.80	0.34	0.37	15.90	0.14	0.57
10	2.90	1.40	3.55	0.31	0.38	15.92	0.12	0.57
11	--	--	--	--	--	--	--	--
12	4.09	0.99	5.32	0.30	0.43	13.55	0.12	0.59
13	6.28	2.30	5.50	0.21	0.42	12.10	0.14	0.70
14	6.25	1.52	5.52	0.25	0.46	12.08	0.15	0.77
15	7.38	1.92	--	0.25	--	10.80	0.23	0.97
16	7.39	2.00	--	0.21	--	10.79	0.21	0.97
17	7.94	2.00	--	0.19	--	10.05	0.24	1.10
18	7.96	1.80	--	0.19	--	10.08	0.24	1.09

- Airblast Penetration 1983 -

Shot 13

27-JUN-84 08:57:08

gauge no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa- msec)	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa- msec)
1	0.69	0.05	0.80	1.45	0.27	---	---	---
2	0.70	0.09	0.90	1.06	0.22	---	---	---
3	1.13	0.07	0.75	1.01	0.14	---	---	---
4	1.09	0.07	1.30	0.79	0.21	---	---	---
5	---	---	---	---	---	---	---	---
6	1.53	0.07	1.20	0.71	0.15	---	---	---
7	2.72	0.38	2.69	0.28	0.20	19.43	0.08	0.26
8	2.75	0.39	2.55	0.34	0.22	19.46	0.09	0.27
9	3.80	1.15	3.42	0.21	0.26	18.10	0.08	0.32
10	3.80	1.12	3.35	0.21	0.27	18.05	0.09	0.35
11	6.11	1.78	4.25	0.17	0.28	15.49	0.08	0.34
12	6.10	1.72	4.38	0.19	0.29	15.52	0.08	0.36
13	7.61	2.06	4.98	0.16	0.28	13.83	0.09	0.44
14	7.64	2.32	4.75	0.17	0.28	13.89	0.10	0.46
15	8.98	2.45	---	0.14	---	12.53	0.14	0.59
16	8.98	2.72	---	0.14	---	12.50	0.13	0.59
17	9.54	2.15	---	0.14	---	11.80	0.17	0.67
18	9.52	2.62	---	0.13	---	11.78	0.16	0.67

- Airblast Penetration 1983 -

Shot 14

27-JUN-84 09:13:46

gage no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	arriv. time, Ta (msec)	Pmax (MPa)	I max (MPa)	I max (MPa)
1	0.35	--	1.04	3.02	0.30	--	--	--
2	0.41	0.07	1.00	2.32	0.31	--	--	--
3	0.80	--	0.90	1.26	0.19	--	--	--
4	0.70	0.08	1.03	1.21	0.20	--	--	--
5	1.20	0.08	1.96	0.90	0.18	--	--	--
6	1.13	0.09	2.24	0.62	0.16	--	--	--
7	2.35	--	2.15	0.36	0.19	--	--	--
8	2.40	0.50	2.40	0.38	0.21	0.09	0.10	0.32
9	3.40	0.78	2.94	0.26	0.25	0.10	0.10	0.26
10	3.42	0.85	3.25	0.27	0.26	0.09	0.10	0.34
11	5.75	1.26	4.18	0.19	0.28	0.10	0.10	0.36
12	5.75	1.22	4.32	0.22	0.29	0.10	0.10	0.35
13	7.28	2.08	4.02	0.16	0.28	0.11	0.11	0.39
14	7.28	1.70	4.00	0.17	0.30	0.12	0.12	0.43
15	8.52	1.70	--	0.15	--	0.14	0.14	0.47
16	8.53	1.83	--	0.15	--	0.14	0.14	0.59
17	9.20	--	--	0.14	--	0.17	0.17	0.60
18	9.17	--	--	0.14	--	0.17	0.17	0.67
								0.69

- Airblast Penetration 1983 -

Shot 15

27-JUN-84 09:21:18

sage no.	First Pulse				Second Pulse			
	arriv. time, Td (msec)	inter. time, T00 (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa) Hsec)	arriv. time, Td (msec)	Pmax (MPa)	Imax (MPa) Hsec)
1	0.55	--	1.75	1.26	0.19	--	--	--
2	0.69	0.10	1.85	1.93	0.23	--	--	--
3	1.10	--	1.55	0.83	0.09	--	--	--
4	1.03	0.09	1.10	0.67	0.14	--	--	--
5	1.61	0.07	2.60	0.74	0.12	--	--	--
6	1.55	0.08	2.14	0.47	0.08	--	--	--
7	2.89	0.53	3.15	0.19	0.14	--	--	--
8	2.92	0.55	2.82	0.23	0.15	20.80	0.07	--
9	4.11	0.90	3.25	0.17	0.18	20.83	0.07	--
10	4.08	0.74	3.38	0.17	0.19	19.38	0.07	--
11	6.64	1.48	4.25	0.13	0.19	19.32	0.08	--
12	6.63	1.35	4.50	0.15	0.20	16.53	0.08	0.21
13	8.30	2.40	4.93	0.12	0.19	16.58	0.08	0.23
14	8.30	1.70	4.82	0.12	0.19	14.83	0.08	0.26
15	9.68	2.05	--	0.11	--	14.85	0.09	0.28
16	9.64	2.30	--	0.10	--	13.45	0.10	0.39
17	10.32	--	--	0.10	--	13.39	0.10	0.39
18	10.32	--	--	0.10	--	12.63	0.11	0.44
						12.63	0.11	0.45

- Airblast Penetration 1983 -

Shot 16

27-JUN-84 09:28:57

gauge no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa)	Imax (MPa)
1	0.51	--	0.83	1.24	--	--	--	--
2	0.51	0.10	0.78	1.12	--	--	--	--
3	1.01	0.09	0.75	0.56	--	--	--	--
4	1.01	0.08	0.72	0.52	--	--	--	--
5	1.56	--	1.96	0.13	--	--	--	--
6	1.56	--	1.43	0.17	--	--	--	--
7	2.29	0.53	1.40	0.13	--	--	--	--
8	2.21	0.41	1.40	0.15	--	--	--	--
9	3.18	0.46	1.65	0.11	--	--	--	--
10	3.14	0.41	1.70	0.14	--	--	--	--
11	7.33	0.95	2.76	0.08	17.96	0.03	0.08	0.08
12	7.30	1.12	2.60	0.08	17.92	0.04	0.08	0.08
13	9.89	1.55	3.35	0.06	15.29	0.05	0.11	0.11
14	9.89	1.50	3.30	0.06	15.31	0.05	0.11	0.11
15	11.38	--	--	0.06	13.76	0.06	0.14	0.14
16	11.38	--	--	0.06	13.74	0.06	0.14	0.14

- Airblast Penetration 1983 -

Shot 17

14-JUN-84 19:47:38

Sage no.	First Pulse				Second Pulse			
	arriv. time, T _a (msec)	inter. time, T _i (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa) msec	arriv. time, T _a (msec)	Pmax (MPa)	Imax (MPa) msec
1	0.71	--	1.19	2.07	0.32	--	--	--
2	0.72	0.09	1.05	1.22	0.22	--	--	--
3	1.21	0.05	0.92	0.82	0.04	--	--	--
4	1.20	0.05	0.65	0.55	0.06	--	--	--
5	1.73	--	2.22	0.17	0.05	--	--	--
6	1.75	--	1.76	0.21	0.03	--	--	--
7	2.35	0.44	1.40	0.16	0.09	--	--	--
8	2.36	0.41	1.38	0.18	0.08	--	--	--
9	3.32	0.50	1.91	0.13	0.09	--	--	--
10	3.28	0.38	1.70	0.14	0.09	--	--	--
11	7.40	1.45	3.06	0.08	0.10	17.95	0.05	0.09
12	7.40	1.40	3.12	0.09	0.09	17.95	0.05	0.09
13	9.90	1.55	3.65	0.07	0.09	15.31	0.06	0.16
14	9.91	1.90	3.40	0.07	0.09	15.35	0.06	0.16
15	11.46	2.00	--	0.06	--	13.85	0.06	0.19
16	11.42	1.93	--	0.06	--	13.78	0.06	0.19

- Airblast Penetration 1983 -

Shot 18

14-JUN-84 19:48:16

Sage no.	First Pulse				Second Pulse			
	arriv. time, T _a (msec)	inter. time, T _o (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa) msec	arriv. time, T _a (msec)	Pmax (MPa)	Imax (MPa) msec
1	0.91	--	0.95	2.48	0.50	--	--	--
2	0.91	0.89	1.09	1.06	0.31	--	--	--
3	1.36	0.06	0.86	0.91	0.06	--	--	--
4	1.39	0.07	0.90	0.78	0.09	--	--	--
5	1.89	--	1.65	0.38	0.06	--	--	--
6	1.89	--	1.70	0.37	0.06	--	--	--
7	2.43	0.48	1.90	0.19	0.12	--	--	--
8	2.42	0.50	4.10	0.23	0.12	--	--	--
9	3.30	0.66	2.50	0.16	0.13	--	--	--
10	3.31	0.40	2.50	0.21	0.13	--	--	--
11	7.22	1.00	3.90	0.11	0.14	17.46	0.05	0.19
12	7.16	1.38	5.92	0.12	0.14	17.46	0.06	0.17
13	9.53	1.50	4.50	0.09	0.14	14.95	0.07	0.26
14	9.62	1.65	4.50	0.08	0.14	14.95	0.07	0.26
15	11.05	--	--	0.08	--	13.40	0.08	0.29
16	11.05	--	--	0.08	--	13.42	0.08	0.30

- Airblast Penetration 1983 -

Shot 19

14-JUN-84 19:48:48

gage no.	First Pulse				Second Pulse			
	arriv. time, T ₀ (msec)	inter. time, T ₀₀ (msec)	pos. dur. (msec)	Pmax (MPa)	arriv. time, T ₀ (msec)	Pmax (MPa)	Imax (MPa)	Imax (msec)
1	0.43	0.08	0.80	3.10	--	--	--	--
2	0.42	0.10	0.80	1.61	--	--	--	--
3	0.82	0.05	0.60	1.46	--	--	--	--
4	0.82	0.08	0.70	1.34	--	--	--	--
5	1.28	--	1.88	0.33	--	--	--	--
6	1.25	--	1.80	0.41	--	--	--	--
7	1.80	0.04	1.50	0.21	--	--	--	--
8	1.80	0.40	1.40	0.26	--	--	--	--
9	2.64	0.53	2.40	0.18	--	--	--	--
10	2.63	0.35	2.05	0.23	--	--	--	--
11	6.42	1.40	3.80	0.11	16.60	0.06	0.19	0.19
12	6.42	1.20	3.72	0.12	16.60	0.06	0.17	0.17
13	8.85	1.60	4.30	0.10	14.10	0.07	0.25	0.25
14	8.82	1.40	4.25	0.09	14.08	0.07	0.26	0.26
15	10.25	--	--	0.08	12.56	0.08	0.23	0.23
16	10.25	--	--	0.08	12.58	0.08	0.29	0.29

- Airblast Penetration 1983 -

Shot 29

14-JUN-84 19:49:12

gage no.	-----First Pulse-----				-----Second Pulse-----			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa) msec	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa) msec
1	0.33	--	0.79	2.76	0.34	--	--	--
2	0.32	0.09	0.66	1.12	0.19	--	--	--
3	0.73	0.05	0.78	1.37	0.06	--	--	--
4	0.72	0.06	0.90	1.08	0.08	--	--	--
5	1.20	--	2.50	0.30	0.06	--	--	--
6	1.20	--	3.00	0.33	0.06	--	--	--
7	1.75	0.39	1.43	0.19	0.09	--	--	--
8	1.78	0.40	1.40	0.23	0.09	--	--	--
9	2.65	0.40	1.80	0.16	0.10	--	--	--
10	2.62	0.28	1.90	0.19	0.10	--	--	--
11	6.60	1.28	4.00	0.10	0.11	16.90	0.05	0.14
12	6.60	0.92	2.90	0.10	0.11	16.92	0.06	0.14
13	9.03	0.91	3.60	0.08	0.11	14.33	0.06	0.13
14	9.06	1.00	3.60	0.08	0.11	14.39	0.05	0.13
15	10.52	--	--	0.07	--	12.89	0.07	0.21
16	10.46	--	--	0.07	--	12.80	0.07	0.22

- Airblast Penetration 1983 -

Shot 21

14-JUN-84 19:49:28

sage no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa) hsec	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa) hsec
1	0.22	--	0.75	5.52	--	--	--	--
2	0.20	--	0.70	1.43	0.24	--	--	--
3	0.53	--	0.68	2.23	0.09	--	--	--
4	0.53	0.05	0.68	1.63	0.10	--	--	--
5	0.94	--	2.60	0.57	0.08	--	--	--
6	0.96	--	3.00	0.47	0.09	--	--	--
7	1.44	0.50	2.78	0.23	0.13	--	--	--
8	1.45	0.31	2.48	0.27	0.14	--	--	--
9	2.28	0.48	2.80	0.19	0.14	--	--	--
10	2.26	0.38	2.80	0.23	0.15	--	--	--
11	6.00	1.72	4.40	0.12	0.16	16.05	0.06	0.22
12	6.00	0.60	4.40	0.14	0.16	16.09	0.06	0.21
13	8.38	1.35	5.05	0.10	0.17	13.60	0.07	0.28
14	8.38	1.60	5.05	0.10	0.17	13.60	0.07	0.28
15	9.80	--	--	0.08	--	12.12	0.09	0.34
16	9.80	--	--	0.08	--	12.08	0.09	0.35

- Airblast Penetration 1983 -

Shot 22

14-JUN-84 19:49:43

page no.	-----First Pulse-----				-----Second Pulse-----			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	IMax (MPa- msec)	arriv. time, Ta (msec)	Pmax (MPa)	IMax (MPa- msec)
1	0.22	--	--	5.52	--	--	--	--
2	0.23	0.66	0.69	3.08	0.46	--	--	--
3	0.44	0.08	1.13	0.63	0.08	--	--	--
4	0.46	0.08	2.33	1.92	0.34	--	--	--
5	0.76	--	3.50	1.06	0.25	--	--	--
6	0.76	--	3.00	1.01	0.28	--	--	--
7	1.13	0.28	4.40	0.41	0.31	--	--	--
8	1.13	--	4.40	0.45	0.33	--	--	--
9	1.80	--	4.60	0.39	0.34	--	--	--
10	1.79	0.30	4.40	0.40	0.39	--	--	--
11	4.96	1.10	6.30	0.19	0.38	14.30	0.08	0.56
12	4.92	1.00	6.20	0.23	0.40	14.30	0.10	0.53
13	7.00	1.30	--	0.19	--	12.00	0.14	0.73
14	7.02	1.50	--	0.16	--	12.00	0.14	0.77
15	8.25	--	--	0.15	--	10.50	0.18	0.90
16	8.25	--	--	0.15	--	10.50	0.17	0.91

- Airblast Penetration 1983 -

Shot 23

14-JUN-84 19:49:58

Sage no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa- msec)	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa- msec)
1	0.83	--	1.10	0.81	0.26	--	--	--
2	0.90	0.12	1.30	0.59	0.23	--	--	--
3	0.90	0.14	1.42	0.90	0.25	--	--	--
4	0.90	0.18	1.22	0.83	0.32	--	--	--
5	1.18	0.14	--	0.81	0.34	--	--	--
6	1.18	0.15	1.28	1.19	0.32	--	--	--
7	1.52	0.40	3.82	0.53	0.27	--	--	--
8	1.50	0.35	3.60	0.56	0.26	--	--	--
9	1.93	0.13	2.55	0.62	0.26	--	--	--
10	1.93	0.22	2.10	0.70	0.34	--	--	--
11	2.84	--	3.10	0.39	0.59	--	--	--
12	2.83	--	3.10	0.39	0.40	--	--	--
13	6.03	1.50	7.00	0.20	0.40	19.70	0.06	--
14	6.03	0.55	7.10	0.24	0.44	19.68	0.07	0.72
15	9.10	3.10	--	0.17	--	16.28	0.10	0.72
16	9.08	2.40	--	0.17	--	16.29	0.10	1.06
17	11.60	--	--	0.13	--	13.10	0.16	1.06
18	11.62	--	--	0.13	--	13.13	0.16	1.06

- Airblast Penetration 1983 -

Shot 24

14-JUN-84 19:50:13

Sage no.	First Pulse				Second Pulse			
	arriv. time, T _a (msec)	inter. time, T _o (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa) msec	arriv. time, T _a (msec)	Pmax (MPa)	Imax (MPa) msec
1	0.22	--	0.62	2.21	0.19	--	--	--
2	0.25	0.09	0.73	1.04	0.17	--	--	--
3	0.29	0.10	0.75	1.26	0.19	--	--	--
4	0.32	0.09	0.70	2.10	0.23	--	--	--
5	0.51	0.10	0.79	1.12	0.22	--	--	--
6	0.51	0.09	1.10	1.94	0.27	--	--	--
7	0.91	0.22	1.40	0.67	0.17	--	--	--
8	0.79	--	1.10	0.69	0.19	--	--	--
9	1.22	0.21	1.20	0.80	0.19	--	--	--
10	1.22	0.20	1.70	0.64	0.23	--	--	--
11	2.13	0.24	2.50	0.39	0.26	--	--	--
12	2.12	0.21	2.40	0.37	0.27	--	--	--
13	5.38	1.00	4.50	0.19	0.28	18.83	0.07	--
14	5.36	0.70	4.40	0.22	0.29	18.82	0.08	--
15	8.40	2.05	5.90	0.15	0.31	15.48	0.09	0.49
16	8.40	2.21	5.90	0.14	0.31	15.47	0.08	0.47
17	10.95	--	--	0.12	--	12.45	0.14	0.74
18	10.99	--	--	0.12	--	12.50	0.15	0.74

- Airblast Penetration 1983 -

Shot 25

14-JUN-84 19:50:32

sage no.	First Pulse			Second Pulse		
	arriv. time, To (msec)	inter. time, Too (msec)	pos. dur. (msec)	PMAX (MPa)	IMAX (MPa)	arriv. time, To (msec)
1	0.33	--	1.03	1.71	0.29	--
2	0.32	--	1.11	1.41	0.26	--
3	0.40	0.10	1.00	1.95	0.27	--
4	0.37	--	1.23	1.77	0.33	--
5	0.59	--	1.20	2.04	0.33	--
6	0.59	--	1.25	2.77	0.42	--
7	0.83	--	1.55	0.77	0.26	--
8	0.83	0.02	1.40	1.20	0.26	--
9	1.18	0.02	1.35	0.93	0.32	--
10	1.18	--	1.80	0.86	0.32	--
11	1.93	0.35	2.90	0.52	0.39	--
12	1.93	0.42	2.78	0.58	0.39	--
13	4.73	1.28	5.00	0.25	0.41	17.43
14	4.73	0.40	5.05	0.33	0.41	17.43
15	7.50	1.50	6.70	0.21	0.46	14.26
16	7.43	1.90	6.79	0.20	0.44	14.22
17	9.88	--	--	0.16	--	11.31
18	9.84	--	--	0.18	--	11.31
						0.79
						0.78
						1.17
						1.22

- Airblast Penetration 1983 -

Shot 26

14-JUN-84 19:50:47

page no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa) msec	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa) msec
1	0.15	0.07	1.33	2.39	0.32	--	--	--
2	--	--	--	--	--	--	--	--
3	0.20	0.05	1.30	2.90	0.30	--	--	--
4	0.19	0.06	1.53	3.10	0.39	--	--	--
5	0.35	0.06	1.50	1.64	0.28	--	--	--
6	0.35	0.05	1.18	2.00	0.40	--	--	--
7	0.55	0.20	2.10	1.06	0.33	--	--	--
8	0.56	0.14	2.00	1.24	0.32	--	--	--
9	0.88	0.24	1.72	1.03	0.34	--	--	--
10	0.83	--	2.49	1.00	0.38	--	--	--
11	--	--	--	--	--	--	--	--
12	1.56	--	3.00	0.30	0.13	--	--	--
13	--	0.92	5.70	0.29	0.48	--	--	--
14	--	0.75	5.80	0.33	0.48	--	--	--
15	--	1.60	--	0.25	--	--	--	--
16	--	2.00	--	0.23	--	--	--	--
17	--	--	--	0.21	--	--	0.28	--
18	--	--	--	0.21	--	--	0.28	--

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Shot 27

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Sage no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa)	Imax (msec)
1	0.41	0.14	1.07	1.52	0.42	--	--	--
2	--	--	--	--	--	--	--	--
3	0.47	0.08	1.28	1.76	0.39	--	--	--
4	0.48	0.08	1.05	2.26	0.52	--	--	--
5	0.64	0.09	1.10	1.28	0.30	--	--	--
6	0.65	0.09	1.29	2.19	0.51	--	--	--
7	0.89	0.21	1.72	1.28	0.43	--	--	--
8	0.84	0.20	1.49	1.63	0.43	--	--	--
9	1.17	0.19	1.72	1.66	0.57	--	--	--
10	1.13	--	1.75	1.12	0.53	--	--	--
11	1.75	--	2.65	0.54	0.42	--	--	--
12	1.72	0.13	2.82	0.33	0.17	--	--	--
13	4.20	--	5.50	0.29	0.48	16.62	0.10	--
14	4.20	0.55	5.85	0.38	0.48	16.65	0.10	0.93
15	6.90	1.80	--	0.24	--	13.60	0.14	0.93
16	6.92	1.75	--	0.23	--	13.60	0.14	1.46
17	9.20	--	--	0.19	--	10.62	0.26	1.57
18	9.19	--	--	0.21	--	10.68	0.28	--

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Shot 28

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gauge no.	-----First Pulse-----				-----Second Pulse-----			
	arriv. time, t _a (msec)	inter. time, t _o (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa) msec	arriv. time, t _a (msec)	Pmax (MPa)	Imax (MPa) msec
1	0.12	0.05	0.83	3.36	0.34	--	--	--
2	--	--	--	--	--	--	--	--
3	0.16	0.06	0.75	2.97	0.39	--	--	--
4	0.19	0.05	1.00	4.31	0.48	--	--	--
5	0.30	0.05	1.20	1.72	0.32	--	--	--
6	0.30	0.05	1.20	2.90	0.56	--	--	--
7	0.46	0.12	2.20	1.66	0.46	--	--	--
8	0.47	0.12	2.15	1.53	0.46	--	--	--
9	0.73	0.12	1.85	1.50	0.48	--	--	--
10	0.73	0.10	2.72	1.76	0.55	--	--	--
11	1.34	0.20	3.38	0.72	0.41	--	--	--
12	1.35	--	3.25	0.40	0.17	--	--	--
13	3.70	1.25	5.70	0.38	0.59	15.38	0.12	--
14	3.75	1.20	6.00	0.41	0.61	15.40	0.12	--
15	6.15	1.25	--	0.34	--	12.50	0.19	1.28
16	6.12	1.45	--	0.32	--	12.48	0.19	1.26
17	8.28	--	--	0.28	--	9.68	0.38	1.99
18	8.30	--	--	0.26	--	9.65	0.40	2.02

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Shot 29

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gauge no.	First Pulse				Second Pulse			
	arriv. time, Ta (Msec)	inter. time, Td (Msec)	pos. dur. (Msec)	Pmax (MPa)	IMax (MPa) msec)	arriv. time, Ta (Msec)	Pmax (MPa)	IMax (MPa) msec)
1	0.18	--	1.05	4.19	0.51	--	--	--
2	--	--	--	--	--	--	--	--
3	0.21	--	0.98	3.45	0.52	--	--	--
4	0.21	0.06	1.31	3.79	0.70	--	--	--
5	0.33	0.07	1.34	4.14	0.81	--	--	--
6	0.33	0.09	1.28	4.00	0.83	--	--	--
7	0.48	0.10	2.73	2.12	0.69	--	--	--
8	0.49	0.10	1.96	2.59	0.69	--	--	--
9	0.70	--	1.82	1.79	0.72	--	--	--
10	0.59	0.20	3.05	1.86	0.80	--	--	--
11	1.22	0.17	3.00	1.14	0.59	--	--	--
12	1.20	--	2.62	0.72	0.54	--	--	--
13	3.24	0.90	0.30	0.41	0.69	14.12	0.07	--
14	3.28	--	7.40	0.41	0.47	14.20	0.07	--
15	5.45	1.21	--	0.48	--	11.42	0.28	1.97
16	5.40	1.50	--	0.44	--	11.40	0.28	1.94
17	--	--	--	--	--	--	--	--
18	7.35	--	--	0.23	--	0.70	0.43	2.13

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Shot 30

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page no.	First Pulse				Second Pulse			
	arriv. time, Ta (msec)	inter. time, Too (msec)	pos. dur. (msec)	Pmax (MPa)	Imax (MPa) msec	arriv. time, Ta (msec)	Pmax (MPa)	Imax (MPa) msec
1	0.21	--	--	4.55	0.99	--	--	--
2	--	--	--	--	--	--	--	--
3	0.25	0.05	3.10	3.45	0.77	--	--	--
4	0.24	0.06	--	4.14	--	--	--	--
5	0.37	0.07	2.05	4.61	0.99	--	--	--
6	0.37	0.07	3.42	4.33	1.01	--	--	--
7	0.51	0.18	4.05	2.22	0.81	--	--	--
8	0.53	0.10	3.40	2.41	0.79	--	--	--
9	0.72	0.15	2.50	2.41	0.89	--	--	--
10	0.72	0.11	3.56	2.41	0.97	--	--	--
11	1.19	--	4.53	1.02	0.75	--	--	--
12	1.21	--	4.28	1.00	0.66	--	--	--
13	3.15	0.40	9.32	0.54	0.90	13.64	0.08	1.30
14	3.15	--	8.48	0.46	0.59	13.62	0.07	0.82
15	5.18	1.91	--	0.54	--	10.92	0.31	2.50
16	5.18	--	--	0.48	--	10.92	0.31	2.41
17	--	--	--	--	--	--	--	--
18	6.98	--	--	0.21	--	8.52	0.38	1.85